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WASTEFULNESS AND ITS CORRECTION IN THE OPERATION OF PUMPING STATIONS[1]

By T. R. Hughes[2]

I am going to discuss problems in connection with driving some minor main service units, auxiliary and boiler room equipment in pumping stations. Frequently the largest wastes in a pumping station are through the small units and they usually present the most difficult problem to the designer. Here, I am merely suggesting a number of solutions which have in some cases proved suitable. None of them are new or unique, but possibly through discussing these various applications those who have these problems to solve will have some solution suggested to them.

In order to study the possible savings in pumping station operation, it is helpful to have some criterion with which the operation of the plant may be compared. For each plant a study should be made, but it is helpful to have, in addition, data on other plants with which to compare it.

An analysis of fuel costs for various sizes and types of pumping stations is given in table 1. The particular plants selected and analyzed here are ones which are thoroughly comparable with the exception of

[1] Presented before the St. Louis Convention, June 5, 1930.

[2] Mechanical Engineer, American Water Works and Electric Company, New York, N. Y.

numbers 6, 7 and 9. These three have both main service and low service pumpage, while the others are all single pumpage plants; that is, they have no low service. The average water horsepower developed by the plant, that is, the useful work accomplished in raising water, and the cost per water horsepower for coal at 12,000 B.T.U. and $4.00 per ton are shown. These are as nearly comparable as any figures when trying to compare various plants.

TABLE 1

Comparison of fuel costs for various types of pump station equipment

	WATER HORSEPOWER	COAL	BRITISH THERMAL UNITS, THOUSANDS	COAL	
				Cost 12,000 B.T.U., $4 per ton	Cost per W.H.P. hr.
Direct Acting Equipment, Single Pumpage					
		tons			
1	62	1,200	12.5	$5,000	0.92
2	63	1,345	11.5	5,150	0.935
3	189	2,336	12.5	9,720	0.589
Crank and Flywheel, Cross Compound, Single Pumpage					
4	89	1,200	11.5	4,600	0.59
5	160	1,700	12.0	6,800	0.48
Crank and Flywheel, Cross Compound, and L. S. Water Turbine					
6	185	2,650	10.5	9,280	0.573
7	282	2,600	12.5	10,800	0.437
Turbine Drive					
8	238	2,810	12.5	11,700	0.56
9	702	8,270	10.0	27,500	0.45

Care has been taken in selecting the plants studied to get each as a good representative for its size and type. They are all efficiently operated plants. The study was not extended to large plants because, in general, one over 300 water horsepower, (equivalent to pumping 7 m.g.d. against 245 feet total head), is too complicated to compare without detailed analysis.

The data from the preceding table are plotted in figure 1 so that the relation of the various plants may be easily seen.

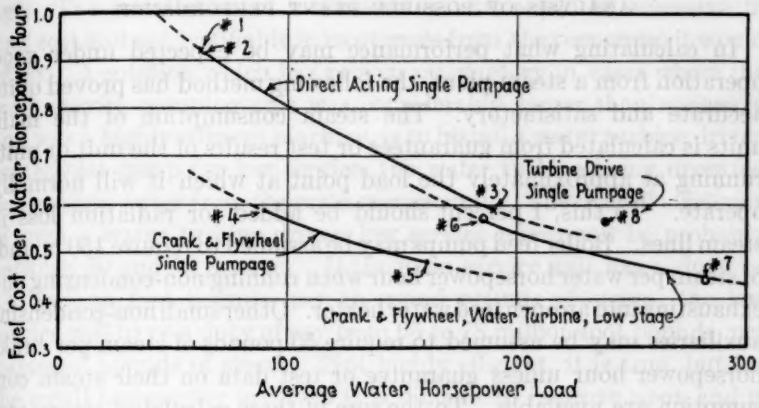

FIG. 1. COMPARISON OF FUEL COSTS FOR DIFFERENT TYPES OF PUMPING MACHINERY

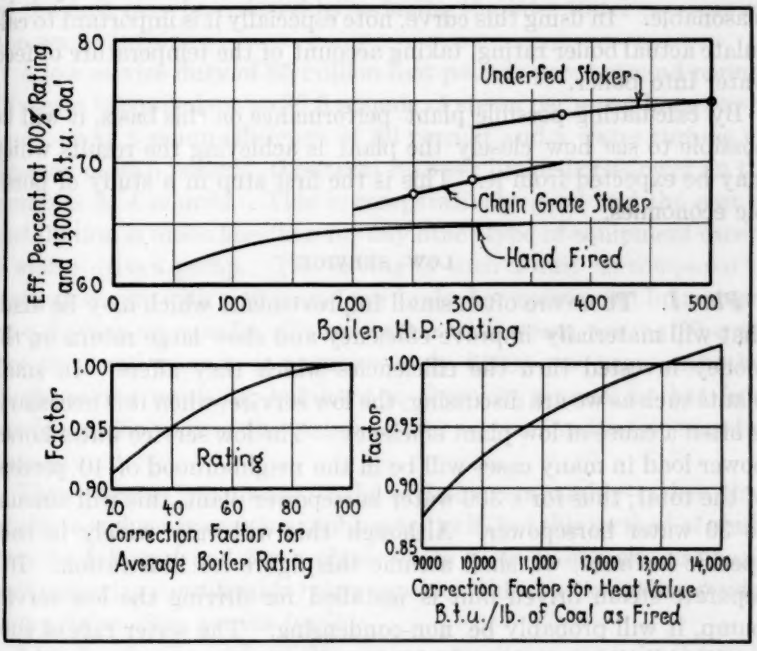

FIG. 2. BOILER EFFICIENCY CURVES

ANALYSIS OF POSSIBLE PLANT PERFORMANCE

In calculating what performance may be expected under good operation from a steam plant, the following method has proved quite accurate and satisfactory. The steam consumption of the main units is calculated from guarantees or test results of the unit or units running at approximately the load point at which it will normally operate. To this, 1 percent should be added for radiation loss in steam lines. Boiler feed pumps may be assumed to require 150 pounds of steam per water horsepower hour when running non-condensing and exhausting into an open feed water heater. Other small non-condensing auxiliaries may be assumed to require 50 pounds of steam per brake horsepower hour unless guarantee or test data on their steam consumption are available. To the sum of these calculated steam consumption figures should be added 5 percent for traps, heating, blowdown and the like. In order to calculate boiler efficiency, figure 2 has been drawn up in our office and the results obtained from it have proven reasonable. In using this curve, note especially it is important to calculate actual boiler rating, taking account of the temperature of feed water into boiler.

By calculating possible plant performance on this basis, it will be possible to see how closely the plant is achieving the results which may be expected from it. This is the first step in a study of possible economies.

LOW SERVICE

Plan I. There are often small improvements which may be made that will materially improve efficiency and show large return on the money invested thru the efficiencies which they affect. In small plants such as we are discussing, the low service, when it is necessary, is often a cause of low plant efficiency. The low service water horsepower load in many cases will be in the neighborhood of 10 percent of the total; thus for a 300 water horsepower plant, this will amount to 30 water horsepower. Although this will vary widely in each specific instance, we shall assume this figure for illustration. If a separate steam driven unit is installed for driving the low service pump, it will probably be non-condensing. The water rate of such a unit will be approximately 50 pounds per water horsepower hour, if we assume it to be an engine driven centrifugal pump, requiring a total of 2000 pounds per hour, corresponding to a duty of 39.6 million foot pounds per thousand pounds of steam. This is expensive pump-

age. The installation of a condensing unit would be excessive in first cost and not justifiable in most cases from the economies it would effect. A solution which has proven satisfactory in cases where the main service pumping unit was considerably larger than necessary and was a highly efficient machine, is to install a water turbine driven centrifugal pump for low service, the water turbine being operated by pressure water from the main service unit. The overall efficiency of such a water turbine driven low service pump will be probably between 50 and 60 percent. If the main service unit has a duty of 130 million foot pounds, per thousand pounds of steam, the low service will have a duty of say from 65 to 78 million foot pounds, per thousand pounds of steam. Not highly efficient, it is true, but for the small horsepower involved it is difficult to improve upon and it operates with almost no care or trouble. Maintenance is low since the cost of all the parts of the unit is relatively small and the cost for oil, grease, etc., is almost nothing. When necessary the pumpage of the unit may be reduced by reducing the inlet water pressure on the water turbine.

A low service duty of 65 million foot pounds per thousand pounds of steam is equivalent to 30.5 pounds of steam per water horsepower hour, or at a pump efficiency of 80 percent and a water turbine efficiency of 62.5 percent, the steam rate per brake horsepower on the pump is 24.4 pounds. This is comparatively good and the cost of installation is much less than for any other type of equipment except a motor driven pump. The saving of such a unit as compared to a steam engine with a 40 pound per brake horsepower per hour steam rate driving an equally efficient pump with steam costing 30 cents per thousand pounds is approximately $1000 per year. Another direct saving resulting, but hard to show, in general, is that from increased efficiency of the main unit due to running it at or near full capacity.

These figures are meant to be strictly comparable rather than absolute and every case is a problem in itself, but this method of study may be followed and for a plant where there is one efficient main unit operating considerably below capacity, this solution of low service pump drive often proves feasible.

Plan 2. In cases where there is no capacity to spare in the main service unit and the low service is in need of replacement, a motor driven low service pump operated from purchased power may prove a satisfactory solution. An installation of this type gives practically

no operating trouble and one is not embarrassed by short outages of power since usually clear water basins may be drawn on for half an hour or so. This type of installation is probably the cheapest as far as first cost is concerned. The operating cost of the 30 water horsepower load at 75 percent overall efficiency with power costing 1.5 cents per kilowatt hour will be $3950.50 per year. A steam engine driving a pump of 80 percent efficiency, steam rate 40 pounds per brake horsepower hour, steam cost 30 cents per thousand pounds, will be $3940. The small difference in operating fuel cost will be more than made up in lubricants, and the installation cost will be less than that for steam engine drive. Although the electric load is small to the power company, it has a high load factor and usually good rates will be available.

Plan 3. In a plant where the main operating unit is a steam turbine driven centrifugal pump, a generator may sometimes be connected to the outboard end of the pump shaft, driven by the main turbine, and used to supply power for a motor driven low service pump. This, of course, is only possible when there is ample capacity in the turbine, gears and pump shaft. If the main pumping unit is operated at variable speed according to the demand of the system, it will prove more satisfactory to install a direct current generator, since with this type of equipment, the speed of the driven units will not vary much with variation of speed of the turbine. In purchasing the generator care should be taken to obtain a compound wound, direct current generator so designed that full voltage may be carried when the turbine is operating at minimum speed and the generator is fully loaded. Such a condition, of course, will not often occur since during periods of reduced main service pumpage, reduced low service pumpage will also be desired, but operating difficulties will be overcome if it is arranged so that full low service capacity will be available at all times. The generator should also be designed so that at full turbine speed, the generator voltage will not exceed normal voltages even if the generator load is light. When the main service unit is operated at constant speed, an alternating current installation will be entirely suitable.

Assuming the total average load on the station to be 300 water horsepower and, of this, 30 water horsepower low service load, the main service load will be 270 water horsepower at approximately 83 percent pump efficiency or 325 brake horsepower. The low service load at the turbine shaft taking 72 percent low service pump efficiency

overall and 90 percent generator efficiency, will be 46.3 brake horsepower. Let us assume that 370 is the rated full load capacity of the turbine and for steam conditions of 150 pounds G.=100°F. the water rate is 13.0 pounds per brake horsepower hour. This will require approximately 600 pounds of steam per hour, using the straight water rate of the machine. Actually, the incremental water rate of this additional load will be somewhat less. The water rate per water horsepower hour at the low service will then be 20.0 pounds. This compares favorably with any other type of individual drive for this load. It is simple to operate and maintenance costs are low.

AUXILIARY DRIVES

In plants where there are a number of small auxiliary units, such as fans, stoker engines, sump pumps, and often motors for driving small pieces of equipment in the purification plant, if it is adjacent to the pumping plant, the generator direct-connected to the outboard shaft of the main service turbine driven pump may prove a simple solution. Of course, it will be necessary, if motors are now installed in the purification plant, to have a standby connection with the power company. In case of the small auxiliary in the pumping station, they will be duplicated by steam units normally.

If a number of small auxiliaries in the pumping station are converted from non-condensing steam drive to electric drive, there will probably be a deficiency of exhaust steam for feed water heating. If this is the case, it will be necessary to bleed steam from the turbine into the feed water heater in order to keep the temperature of the boiler feed water 180°F. leaving the open heater.

A 400 horsepower turbine similar to the other discussed for low vice drive will have a water rate of approximately 13 pounds per rake horsepower with steam at 150 pounds G.=100°F. The generator brake horsepower added, would be, say 25. With steam at 30 cents per thousand pounds, the cost of electric energy produced for 325 pounds of steam produced per hour and at 90 percent generator efficiency gives a power cost of 0.58 cent per kilowatt hour.

In districts where power for small loads is high in price, this type of installation may effect considerable economies.

The problem in pumping stations or any power plant of economical drive for small units is difficult, and it is for this reason that I have dealt at such length on the drive for low service pumps and auxiliaries. I have kept the same size low service throughout so that ready com-

parison can be made between the various plans. Any individual problem must be solved on its own merits, and only the method of solution may be dealt with here.

MISCELLANEOUS SUGGESTIONS

Feed water treatment. In a plant in which reciprocating equipment is installed, the problem of obtaining proper boiler feed water is always difficult. If 100 percent raw make-up is fed to the boilers, much scale will be formed and very dirty steam produced. Usually, engine condensate cannot be fed directly to boilers without carrying with it large quantities of oil, which will be left in the boiler and produce, most unsatisfactory results. In several plants, this problem has been met by clarifying the oily condensate. If a small amount of lime and alum, just enough to form a satisfactory floc, is fed to the condensate, and it is then filtered through a sand bed, a very clear effluent entirely free from oil will result. If the filter is backwashed daily and boiled out periodically with soda and steam, the sand will keep clean and in good condition for several years. If care is taken to return all condensate, make-up may be kept to from 5 to 10 percent of the total boiler feed, and little or no scale will be formed in the boilers. In one instance, boiler efficiency was raised over 5 percent by feeding clear condensate instead of all raw water make-up and the labor cost of boiler cleaning reduced to almost nothing. A plant of 200 water horsepower load will have a fuel cost of, say 0.55 cent per water horsepower hour, or $9630.00 per year. If the boilers had in them a heavy deposit scale and efficiency were decreased 5 percent, the loss in fuel would amount to $480.00 per year, and this may easily occur. The cost of installation of the filter would probably not exceed $1500.00.

Feed water heating. Common practice in central stations is to bleed steam from the main turbines and use it for feed water heating; this may readily be done with reciprocating equipment also. The steam should be bled at a pressure at least 5 pounds above atmosphere and care should be taken to see that the pressure at the point of extraction is at all times above atmosphere. If the pressure of the bled steam goes below atmosphere, the installation is more complicated, and it takes very close observation to keep it operating properly. If there is an open heater in the plant for which there is not sufficient exhaust steam to raise feed water to 180°F., steam may be

bled to it through either a hand-operated valve or, if the load varies over a wide range, through a temperature regulating valve.

If an open heater is already in operation, and there is sufficient steam to keep the feed water to 180°F. (a higher temperature in an open heater causes excessive waste), a closed heater may be installed through which the boiler feed water, after leaving the boiler feed pump, passes. The bled steam will be used for heating the closed heater, the condensed steam being drained into the open heater. The economy of this arrangement is dependent upon the temperature of the bled steam available for it, and it must be high enough to give out considerable heat in the closed heater in order to justify the expense of the installation.

If approximately 50 percent of the steam bled must be replaced by live steam, costing 30 cents per thousand pounds, the cost of the steam bled is 15 cents per thousand pounds. Heat in live steam costs about 30 cents per million B.t.u. and heat in bled steam just a little more than 15 cents per million, since some heat is used from the live steam before bleeding. If a heater is installed at a cost of $750.00, money, taxes, etc., costing 15 percent, we must save $113.00 per year or 750 million B.t.u. For boiler feed of 5000 pounds per hour, the temperature must be raised 17.2°F. Thus, it will be seen that a closed heater is often not feasible on a reciprocating unit since steam at a proper pressure may not be available.

Bleeding steam from an engine after it has been partly used, in doing useful work, is a highly efficient method of heating feed water. For estimating purposes, it will be found that approximately 50 percent of the steam bled will have to be replaced by high pressure steam. The bled steam, however, instead of being expanded to the condenser and there losing all of its latent heat to the circulating water, gives this heat up to the feed water where it may again be used.

Open heaters often waste considerable quantities of steam, especially when the temperature of the heater is carried above 180°F. Even at this temperature, the loss is appreciable. This loss may be very materially reduced by installing on the vent of the heater a small jet condenser. These may be readily made at the plant and may be designed in any one of a number of ways. The boiler feed water entering the open heater may be sprayed into the vent and thus used to condense the steam escaping and consuming the heat. It should be arranged so that the vent remains open at all times and no pressure can be built up in the open heater.

These various points by which savings may be effected are doubtless familiar to you. I have tried to make some analysis of the economies to be effected by most of them so that the point at which they fit in may best be shown. The figures assumed I have tried to make reasonable and comparable. I have tried to interpret all savings in money as well as in B.t.u., feeling that too often savings are spoken of in too glowing terms when the dollar value of them is overlooked.

DISCUSSION

A. D. COUCH:[3] The writer does not in any way wish to detract from Mr. Hughes remarks, but for those of us who are charged with plant economy it is a very easy matter sometimes to overstress an operating economy which might not actually be a real economy when all things are considered. This is especially true when even a small capital investment is necessary. This may be more clearly illustrated by a concrete example:

Several years ago our company purchased a very well managed and operated company in the Middle West and after an early inspection it was found that the condensate was not being returned to the feed water heater due to the fact that it was contaminated with oil.

It is every day custom to assume that for every eleven (11°) degree rise in the temperature of the feed water, the overall efficiency of the plant would be increased approximately 1 percent. With this in mind it would seem that some efficiency could be gained by installing an oil extractor to eliminate the oil from the condensate and thereby making the condensate suitable for boiler feed.

Upon investigation of this problem the following data were compiled from actual test.

1. Average winter temperature of water entering heater, 40°F.
2. Average summer temperature of water entering heater, 80°F. Or a mean average temperature of 60°F.
3. Average temperature of condensate leaving condensor is 115°F. or an average increase in temperature of 55°F.

The average evaporation of the boiler per day of twenty-four hours was found to be 55,944 pounds. The average number of pounds of water leaving the condensor was found to be 34,853 pounds or 62.3 percent of the steam available as condensate for boiler feed.

[3] Mechanical Engineer, Community Water Service Company, New York N. Y.

The 34,853 pounds of condensate per day available for return to boilers had an average temperature of 55° higher than water now going to the boilers and means an average increase of 1,016,915 B.t.u. per day.

Coal burned at this station contains 13,000 B.t.u. (dry basis) and with an overall boiler efficiency of 63 percent means a saving in fuel of 234 pounds of coal per day and with a cost per ton or $2.80 would show a saving in favor of recirculating the condensate of 33 cents per day.

To offset this saving it was found that to operate properly an oil extractor would cost 10 cents per day, which is the cost of chemicals only. The initial cost to install an oil extractor would be $700, which when using a fixed charge of 15 percent (made up of interest 8 percent; maintenance 3 percent, depreciation 2 percent, taxes and insurance 2 percent) is $105 per year or 21 cents per day. Thus it will be observed that the net saving per day would be only 2 cents.

Inasmuch as only 62.3 percent of the water evaporated in the boilers is available for recirculation, the makeup water would have to be treated before entering the feed water heater. Thus treatment of the makeup water is necessary whether or not the condensate is returned to the boiler.

The above clearly indicates that under certain conditions in small plants which many water companies operate even though the overall plant efficiency were raised 3 percent, it would be false economy to make the necessary changes to accomplish this operating saving.

K. TOENSFELDT:[4] Wastefulness may be anticipated in the design and may, in this way, be avoided by removing its cause.

Of primary importance is the selection of the proper equipment for the pumping plant in question, which is the equipment that will pump the given amount of water with required reliability for the determined life of the plant at the lowest total cost. With a continuous day and night load such as is found in pumping plants serving large cities and where the fuel cost is half of the total cost of operation, greater weight is given to economy, in the choice of apparatus, while in small plants which may operate only for a part of the day, first cost of the plant may prove the dominant influence. The cost of coal will modify the influences as well as the load factor.

[4] Combustion Engineering Corporation, New York, N. Y.

The total annual cost of pumping water is made up of fixed charges and operating costs. By increasing the capital costs the operating costs may be reduced, i.e., an increase in efficiency may result from high capital expenditure. A point may be reached where fixed charges of additional equipment equal the saving obtained by that equipment and any additions beyond that point result in fixed charges in excess of the savings.

The major influences in determining the lowest total annual cost are:

1. Location of plant.
2. Probable life of plant.
3. Load factor.
4. Fuel.
5. Labor.
6. Water.

Under 1, considerations must be given to:

a. The cost of land.
b. Suitability of location with respect to distribution of water.
c. Suitability of soil for foundations for building and machinery.
d. Accessibility for transport of material, fuel or power.
e. Labor supply.

Where water is pumped to a point of distribution, items *a*, *b* and *c* above involve the study of the lowest combined costs of cost of pumping and cost of delivering water. The pumping costs will vary in accordance with the selection of machinery. Steam, triples or turbines, electric and oil engine driven units will have different overall costs and the total annual cost of the pumping water should be combined with the total annual costs of the pipe line to point of distribution in order to find the lowest total cost. A smaller pipe line will have a lower cost, but higher resistance and will require more head at the station involving a greater capital investment to insure either greater efficiency or greater capacity, and vice versa.

Under *d*, reliability of operation must be given weight with regard to fuel and material supply and in the case of electrically driven pumps with regard to current interruption.

Under 2, consideration must be given to:

f. Nature of business permanency.
g. Probable growth.
h. Life or obsolescence of apparatus chosen.
i. Effect of cost of pumping on water cost.

Fixed charges may be greatly influenced by the assumption of long or short lives for different types of apparatus chosen. A satisfactory method of analysis is to choose a given period of life for the plant at which obsolescence occurs and compare the different types of units on the same life allowing suitable replacement charges over the period.

Under 3, consideration must be given to:

j. Its relation to economy.
k. Its effect on the type of apparatus.
l. Its effect on the cost of apparatus.
m. Its effect on the number of units.
n. Its effect on the rate of operating the units.

Under 4, consideration must be given to:

o. Cost.
p. Quality.
q. Burning quality.
r. Reliability of supply.
s. Possibility of change in quality and price.

These factors will determine the selection of fuel burning, coal storage and coal and ash handling equipment.

Both 3 and 4 combine in influencing the extent to which capital investment should be made in order to obtain efficient operation. In general, pumping plants serving communities have such continuous, uniform, and slowly varying loads, that in the case of steam plants, the fuel firing equipment may be of the simplest form for obtaining high efficiency. Pulverized fuel equipment is not commonly used; instead stokers are usually installed. Depending on the load factor, the price of fuel, and the conduit costs, if involved, the advisability of economizers or air preheaters may or may not be justified.

In the pump room in the case of steam plants the selection of turbine driven pumps or triples, involves not only load factor and fuel costs but also the costs of buildings and foundations. When contemplating the building of a new plant consideration should be given to the reconstruction of the old plant, increasing its output by the installation of apparatus of greater capacity and efficiency. The saving incurred by costly building, pit and foundation construction of a new plant may well justify such consideration.

It is quite impossible in a limited discussion of this kind to cover a major subject such as the economic considerations involved in pumping plant design with its many complex and interrelated influences, and it is merely attempted to list and point out some considerations by way of suggestion that wastefulness in its major sense can be avoided by being met with proper design.

THE NEW WATER SUPPLY OF THE EAST BAY MUNICIPAL UTILITY DISTRICT[1]

By F. W. Hanna[2]

California as a whole, and particularly the southern and central parts, is not favorably situated for the development of cheap abundant water supplies for large concentrated populations on its western border. The state in general consists of four parallel strips extending north and south across it; first, a narrow strip along the Pacific Coast adaptable mainly to the growth of cities, and secondarily to agriculture; second, a low mountainous strip in the Coast Range suitable mainly for grazing; third, a great level interior valley eminently suitable for agriculture; and fourth, the great Sierra Nevada mountain range suitable mainly for grazing, mining, lumbering, and water development.

All of the streams of the Coast Range are relatively small and furnish but limited supplies of water, while those of the Sierra Nevada Mountains receive heavy snows in the winters forming abundant water supplies during the springs and early parts of the summers. In the early history of California, when the coast cities were comparatively small, the run-off from the small streams of the Coast Range were ample to provide for their water needs, but the modern growth of many of these cities has put demands for water beyond the capacities of these streams. Such coast cities as Los Angeles, San Francisco, the East Bay cities, and such interior valley cities as Sacramento and Stockton either have begun, or are beginning to look to the more distant mountain ranges for their water supplies. Los Angeles, some twenty years ago, found it necessary to go beyond the Coast Range to the Sierra Nevada Range distant some 235 miles for its water supply from Owens River and is now looking towards securing water from Colorado River rising in the Rocky Mountain Range. San Francisco also nearly twenty years ago began to look for a supply from Tuolumne River in the Sierra Nevada Mountains some 175 miles distant. In

[1] Presented before the California Section meeting, October 24, 1929.

[2] Chief Engineer and General Manager, The East Bay Municipal Utility District, Oakland, Calif.

1924 the East Bay cities, having outgrown their local supplies from the Coast Range, began to develop a supply from a project on the Mokelumne River in the Sierra Nevada Mountains about 100 miles distant. Sacramento is now initiating a project on Silver Creek, a branch of the American River, in the Sierra Nevada mountains over 60 miles distant, and Stockton is interesting itself in a mountain source of supply.

The East Bay cities, in order to bring in their distant water supply, formed the East Bay Municipal Utility District in 1923. This District is comprised of Richmond, El Cerrito, Albany, Berkeley, Emeryville, Piedmont, Oakland, Alameda and San Leandro, all situated along the east shore of San Francisco Bay and all forming in effect a single consolidated city. The total area of the District is approximately 78,000 acres, and it contains at the present time about one-half million people.

A study of the population of this group of cities, of its rate of growth, and its natural advantages, leads to the conclusion that it is destined to become a large metropolitan area with a population of around one million people by the middle of the present century, and two million or more people by the end thereof. Such increases in population will require a daily water supply of 100,000,000 by 1950 and 200,000,000 gallons by 2,000.

At the time of initiating the construction of their mountain supply, the East Bay cities were relying for their water mainly on San Leandro Creek and San Pablo Creek and a group of wells near San Francisco Bay. The estimated long time daily yield from these two creeks, when controlled by the reservors then on them, was about 20,000,000 gallons and that from wells and other sources around 10,000,000 gallons additional, making a total of about 30,000,000 gallons. The average daily usage in 1928 was about 34,000,000 gallons with an average daily use for the maximum month as high as 42,500,000 gallons and as a result the supplies had to be operated at excess capacity. Moreover, the average daily usage has been increasing in the District at the rate of about 1,500,000 gallons annually. The wells furnish a quality of water of more or less objectionable amounts of mineral content, and their waters are much needed for local use outside of the District. As a result these wells either have been or will be abandoned. Consequently the available supply is reduced to about 20,000,000 gallons daily.

THE MOKELUMNE RIVER SOURCE

After a comprehensive investigation of the various distant sources of water supply available for the cities of the East Bay District, the Mokelumne River was selected as providing the most economical source financially and the Pardee Reservoir, situated in the canyon of Mokelumne River about 4 miles northeast of Valley Springs, was found to be the most desirable place for storage. Mokelumne River rises at the crest of the Sierra Nevada Mountains and flows into the San Joaquin River near its junction with the Sacramento River. The drainage area of the river above Pardee dam site is 536 square miles. The river has three principle branches known as the North Fork, the Middle Fork and the South Fork. The North Fork is the main stream and contains more than two-thirds of the entire drainage area and yields more than three fourths of the run-off. It heads at the summit of the Sierras at Round Top Mountain, one of the high peaks of the Sierra Nevada Range. The upper part of the drainage basin has a considerable width but it narrows just below the junction of the North and South Forks and from here on to the great interior valley, the river traverses a narrow canyon with its drainage boundaries very close to it.

The watershed of the Mokelumne River as a whole supports a vegetation ranging from heavy growths in the lower parts to very scant or no growth at the higher altitudes where bare granitic rocks exist. Generally speaking the watershed up to elevation 4000 feet above sea level is well timbered, and taken as a whole there is very little likelihood of large amounts of erosion. While the region once had considerable population engaged in mining, this industry has largely ceased, and the population has been reduced to an average of less than one person per square mile. There is, therefore, very little danger of human pollution, and as a consequence the water is of a fine quality from a biological viewpoint.

Geologically speaking, Archaeozoic and Proterozoic rocks cover practically all of the drainage area of the North Fork, a large portion of that of the Middle Fork and some of that of the South Fork of the Mokelumne drainage basin and Palaeozoic and Mesozoic rocks cover the remainder. The older rocks are comprised principally of igneous granodiorites, and the younger ones mainly of argillite, limestone, quartzite, phthanite and mica schists. There are, therefore, only small amounts of soluble salts entering the water supply from the

surfaces of the upper part of the drainage basin; and the minerals from the oxidized surfaces of the lower part either have been or are being carried away by rain and stream flow as fast as liberated. There is, on the other hand, just sufficient of the sedimentary rocks to give desirable amounts of minerals for domestic water without injuring it for industrial purposes. Chemical analyses of the water as delivered into Pardee Reservoir and to the local District reservoirs show a total mineral content of 81.7, a total carbonate hardness of 28.5, a total non-carbonate hardness of 4.0, giving a total hardness of 32.5 p.p.m. or 1.9 grains per gallon, which indicates a relatively soft water.

In the development of its new water supply, the East Bay Municipal Utility District has constructed the Pardee Reservoir in the foothills of the Sierra Nevada Mountains, the East Bay Aqueduct leading from this to the District and two subsidiary high line aqueducts within the District, and has purchased the old reservoir and distributing system of the East Bay Water Company.

THE PARDEE RESERVOIR

The Pardee reservoir has a gross capacity of approximately 220,000 acres feet of water of which about 200,000 are above the aqueduct outlet leading from it into the District. In the development of the basin in which the water is stored, the geology of the region has had prime bearing. The sedimentary rocks of the Mesozoic era were at some time in later geological history compressed by a tremendous force from the west which crumpled and upturned them. This disturbance was followed soon after, or at the same time, with upward intrusions of igneous material in ridges running at right angles to the present Mokelumne River Channel. These intrusive ridges are hard and difficult to erode while the crumpled sedimentary rocks between are soft and easily eroded. As a consequence the river channel in the igneous rocks is narrow and precipitate and in the sedimentary rocks is broad and sloping. The Pardee Dam is built on one of these igneous ridges, while immediately above it are two broad deep gulches running parallel to the ridge. These with the extension of the Mokelumne River channel through the igneous and upturned sedimentary rocks to the eastward form a natural basin for the storage of water.

This reservoir is controlled by five principal structures, namely: the Pardee Dam already referred to across the main river; the Pardee power plant at the foot of the dam; the South Spillway on the southerly

rim of the reservoir; the Jackson Creek diversion works on the north rim of the reservoir; and the outlet tower at the entrance to the aqueduct.

THE PARDEE DAM

Pardee Dam is one of the largest and most imposing dams in the world. There is only one dam in the United States higher and only two that contain a larger cubical content. This structure is of the gravity type curved in plan to a radius of 1200 feet measured from the upstream face, is 358 feet high, 1347 feet long on the top, 241 feet thick at the base, and 16 feet wide at the top, and contains 615,000 cubic yards of concrete and about the same number of barrels of cement. The structure is provided with radial contraction joints at suitable intervals, a grouting system for the contraction joints, a copper water stop in the contraction joints at the upstream face and a galvanized iron grout stop in the contraction joints at the downstream face. There are four large cast iron pipe sluiceways through the dam, two of 72-inch diameter and two of 42-inch diameter, each controlled at the lower end by means of a Johnson valve and a butterfly valve and at the upper end by means of a Broome roller gate.

THE PARDEE POWER PLANT

The Pardee power plant consists of two turbo generator sets, each of 7,500 kilowatt capacity, of the vertical shaft, revolving field, alternator type designed to generate 3 phase, 60 cycle, 6,600 volt current at 450 revolutions per minute. The current generated by the turbo generator units is transformed at the power house to a line voltage of 100,000. The plant is located in the old river channel at the base of the dam and receives its water through two 72-inch cast iron penstocks leading through the dam and each controlled at the lower face of the dam with a 72-inch butterfly valve and at the upper end by means of a Broome gate.

SPILLWAYS AND APPURTENANCES

The main spillway, known as the South Spillway, is located on a low place in the igneous ridge about 1,000 feet south of the dam and will convey flood water from the reservoir back into the river about 1,500 feet downstream from the dam. This spillway has a carrying capacity of 125,000 second feet, which is about four times the maximum flood flow of the Mokelumne River. It is a magnificent struc-

ture of the ogee type, 847½ feet long, 20 feet high, and has a concrete bridge over the top.

The Jackson Creek diversion structure has for its purpose the diversion of flood waters into Jackson Creek for the benefit of irrigation, if such irrigation should in the future be developed by private parties. It is located about three miles north of the dam at a low place in the divide between the Mokelumne River and that of Jackson Creek. The diversion structure contains sixteen 5-foot by 12-foot siphon spillway compartments of the self-sealing type.

The Pardee reservoir outlet tower consists partly of an underground reinforced concrete shaft and partly of a structure above ground. This tower has an internal diameter of 19 feet, and a total height of 190 feet, of which 70 feet are underground. Water can be taken into the tower at five different levels so that the most potable water in the reservoir can be drawn at any time. Each of the inlets into the tower are controlled by three electrically operated gates and covered with copper fish screens of ¼-inch mesh. The screens can be raised to a platform at the top of the tower and there cleaned with the exception of those at the entrance to the tunnel itself. The inlet capacity of the tower at any one of the levels is 200,000,000 gallons daily.

DISTRIBUTION LINES

The East Bay Aqueduct leads from the Pardee Reservoir to the District and in so doing passes through the foothills of the Sierra Nevada mountains across the deltaic basin of the San Joaquin River and through the Coast Range. It contains four concrete lined tunnels, a reinforced concrete pipe, and a steel pipe line totaling a length of 93.8 miles. The tunnels and the reinforced concrete pipe each have a carrying capacity of 200,000,000 gallons daily, while the present steel pipe line has a carrying capacity of 40,000,000 gallons daily by gravity and 70,000,000 gallons daily when supplemented by a booster plant. The steel pipe line is to be later augmented by two additional lines that will bring the total steel pipe line capacity up to that of the the tunnels and reinforced concrete pipe.

The Pardee Tunnel, in the Sierra foothills, is 8 feet in diameter and 2.2 miles long. The Walnut Creek Tunnel, at the entrance into the Coast Range, is 8 feet in diameter and ½ mile long. Lafayette Tunnel, near the middle of the Coast Range, is 8 feet in diameter and 3 miles long. The Claremont Tunnel, terminating in the western slope of

the Coast Range, is 9 feet in diameter and 3½ miles long. The Miller Aqueduct, intervening between the Walnut Creek and Lafayette Tunnels, is a circular reinforced concrete pipe 9 feet in diameter.

Intervening between the Pardee Tunnel, in the foothills of the Sierras, and the Walnut Creek Tunnel, in the easterly foothills of the Coast Range, is a steel pipe line ranging in diameter from 61 to 65 inches, 81 miles in length, made of steel plates varying in thickness from ⅜- to ½-inch. The three deltaic branches of the San Joaquin River encountered along the line are each crossed with two inverted steel siphons of 54-inch diameter. In general the pipe in the aqueduct was manufactured into sections of 30-foot length by means of electrically welding two plates together. These sections, after being placed in the trench, were joined together by means of either single riveted, or double fillet electrically welded straight bump joints, gas welded butt joints, double fillet electrically welded butt strap joints, and double riveted butt strap joints. The most satisfactory joints proved to be the straight bump joint either of the riveted or the double fillet electrically welded type. The pipe was dipped in Hermastic Dip and wrapped externally with Pabco Pipe Covering adhered to the pipe with Petrolastic Cement except where the pipe was supported above ground across the San Joaquin Delta. The pipe supported above ground was dipped in Hermastic Dip and sprayed with a coat of aluminum paint. The pipe line is provided throughout its length with suitable anchors, air valves, vacuum valves, blow-off valves, automatic wasteways, manholes, and expansion joints.

The East Bay Aqueduct is provided with a Johnson throttle valve and a Venturi meter at the outlet of the Pardee Tunnel; a booster plant of 70,000,000 gallons daily capacity about one mile easterly from the Walnut Creek Tunnel; an aeration weir at the entrance to the Walnut Creek Tunnel; a screening chamber near the entrance to the Lafayette Tunnel; another screening chamber and wasteway at the entrance to the Claremont Tunnel; a chlorinating plant at the outlet of the Claremont Tunnel; and two large steel cylinder reinforced concrete transmission and connecting aqueducts of 48-inch diameter, one leading from the west portal of the Claremont Tunnel a distance of five miles to the northward along the foothills through Berkeley, and another leading from the same point along the foothills through Oakland and Piedmont a distance of five miles southward.

In order to complete its water supply system, the District in 1928 purchased the existing water supply system of the East Bay Water

Company. In the purchase of this system the District acquired four storage reservoirs with a combined capacity of 32,700,000,000 gallons; 50 distribution reservoirs and tanks with a capacity of 298,000,000 gallons; three steam and 31 electric pumping plants with a total capacity of 93,000,000 gallons daily; 4 filter plants of the rapid sand type with a combined capacity of 30,000,000 gallons daily; 8 sterilization plants; over 1400 miles of distributaries; 127,963 metered services; 2,122 hydrants and 44,461 acres of land, in addition to various office buildings and operating equipment. This purchased plant has been operated by the District since December 8, 1928, and the new Mokelumne Project has been operated by it since June 23, 1929.

At the present time, the Pardee Reservoir, all four of the tunnels and the Miller Aqueduct, are completed for a capacity of 200,000,000 gallons daily, and the steel pipe line of the East Bay Aqueduct and appurtenances between the Pardee and Walnut Creek tunnels are completed for a capacity of 70,000,000 gallons daily. The District is, therefore, in a position, at the present time, to furnish 70,000,000 gallons of water daily to its consumers and has, in a large measure, prepared its water system for an ultimate capacity of 200,000,000 gallons daily.

PRECHLORINATION IN RELATION TO THE EFFICIENCY OF WATER FILTRATION PROCESSES[1]

By H. W. Streeter[2] and C. T. Wright[3]

During the past few years the chlorination of water as a preliminary stage of filtration treatment, commonly termed "prechlorination," has been attracting considerable attention in this country both as an auxiliary method for reinforcing filtration plants against overburden due to excessive raw water pollution and as a possible means of effecting economies in the use of coagulants. In a review of progress in water chlorination published in 1928, Enslow[4] described the results recently obtained from this method of treatment in 14 North American cities, thus indicating the extent to which it has become established in routine practice during the past few years.

In this connection it may be of interest to note that the use of prechlorination dates back to the original applications made of chlorine in large-scale water disinfection. In 1904, Houston and McGowan who are credited with being the originators of this method of water treatment on a plant scale, added chlorine, in the form of sodium hypochlorite, to the raw water supplying the Lincoln filters, in the London water system. In 1908, Johnson, who was the American pioneer in water chlorination, added chlorine, as calcium hypochlorite, to the raw water of the Bubbly Creek filters at Chicago.

With the rapid and widespread extension of water chlorination which followed the work of these investigators, the practice of adding chlorine to water prior to filtration treatment became supplanted to a large extent, in the United States, by that of postchlorination, or chlorination after filtration, which in ordinary cases proved to be the

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[4] Enslow, L. H.: Progress in Chlorination of Water. Jour. Amer. Water Works Assoc., vol. 20, No. 6 (December, 1928), pp. 819–846.

more economical and readily controlled method. As early as 1914 it was reported by Longley[5] that this latter method was being followed at over half of the plants surveyed by his committee. At the present time it has become virtually a universal practice in connection with filtration, regardless of the kind or extent of preliminary treatment used prior to filtration.

The revival of prechlorination as a measure of reinforcement for overburdened filtration plants already equipped with postfilter chlorination, thus introducing double-stage chlorination into current water purification practice, has brought this method quite naturally into comparison with other elaborations of ordinary filtration processes such as double-stage coagulation, sedimentation, or filtration. In view of this development and of the fact that most of the tests of the efficacy of prechlorination quite necessarily have been made by comparison of the performance of individual filtration plants over two different periods, one preceding and the other following the institution of this practice, it appeared that a parallel comparative test, covering a single period, of the results obtained from identical treatment of the same raw water, both with and without prechlorination, might afford a more direct index of the extent of improvement in efficiency accomplished by this measure.

Facilities for making such a test were available at a fully equipped experimental water filtration plant of the rapid sand type installed by the United States Public Health Service at Cincinnati in 1924, primarily for another purpose,[6] but well adapted for controlled parallel observations of the character indicated. The prechlorination experiments were made over a period of 16 months extending from July, 1927, to October, 1928, inclusive. In this paper[7] it is proposed to discuss briefly some of the more significant results of these experiments.

[5] Report of Committee on Water Supplies. Sanitary Engineering Section, American Public Health Association, 1914.

[6] See Reprints Nos. 1114 and 1170 from the Public Health Reports, issues of October 1, 1926, and July 15, 1927.

[7] The present paper is the fifth of a series dealing with the result of experimental studies of the efficiency of water purification processes conducted at the experimental plant above designated. For the preceding paper of the series see Public Health Reports for July 4 and 11, 1930, pp. 1521–36 and 1597–1623, respectively.

DESCRIPTION OF EXPERIMENTS

The experimental plant, which has been fully described elsewhere,[8] was arranged so that it could be operated in two parallel and duplicate sections. In operating the plant for these experiments, the raw water was divided as it left the head tank, approximately one half of it flowing through one section of the plant and one half through the other section. The water flowing through the two sections was given as nearly as possible the same rapid sand filtration treatment, except that one portion was prechlorinated just before passing into the sedimentation basin, but shortly after the addition of the coagulant.[9] As the nominal period of retention in the basin was 6 hours, this period represented the time of contact of chlorine with the prechlorinated water before it passed to filter A. The effluents of both filters, A and B, were chlorinated as they passed from each filter into a separate well, where the water was stored for a nominal period of about 20 minutes before being discharged into the final effluent pipe.

After the first month, which constituted a trial period, the plant was operated for 12 months (August, 1927, to July, 1928, inclusive) with the residual chlorine content of the prechlorinated water, as applied to the filters, held within an upper limit of 0.05 p.p.m. during the greater part of the time. During the last three months of the test, this residual was increased gradually up to a maximum of 1.2 p.p.m. in order to observe the effect of heavy prechlorination on the efficiency of filtration. Throughout the entire test period an effort was made to adjust the postchlorination dosage so as to leave a final residual chlorine in the effluent of each filter not exceeding 0.05 p.p.m., an amount falling below the ordinary taste-producing minimum. During the period of heavy prechlorination the final residual chlorine exceeded 0.05 p.p.m. on several occasions, but at no time did it average more than 0.10 p.p.m. for a given day. The coagulant dosage was regulated in accordance with the usual practice and a particular effort was made to maintain the same dosage in the prechlorinated and nonprechlorinated water.

In order to maintain a close check on the residual chlorine content of the water at the various stages of treatment, tests were made hourly

[8] Reprint No. 1114, Public Health Reports (October 1, 1926), pp. 1–9.

[9] It was not practicable to prechlorinate the raw water prior to the addition of the coagulant, though the interval of time between the addition of the coagulant and prechlorination was very little more than one minute.

at each stage throughout the period of the experiments. Samples of water for physical, chemical, and bacteriological examination were collected at each step of treatment, at 8-hour intervals throughout the day and night, with more frequent collections occasionally as required.

RESULTS OF EXPERIMENTS

Period averages. The results of the experiments have been compiled in a series of tables and illustrative charts, to be presented in connection with the text which follows. In figures 1 and 2, based on the data given in table 1, are two block diagrams showing the comparative average numbers of plate-growing bacteria and *B. coli* observed at each stage of treatment, with and without prechlorination, during successive months of the experiment. For convenient reference, the corresponding average amounts of residual chlorine carried in the prechlorinated water after coagulation-sedimentation and in both filter effluents after postchlorination, have been added to the table and plotted in the chart.

The table and the charts show a consistent improvement in the bacterial quality of all of the effluents, applied, filtered, and chlorinated, resulting from prechlorination, except in August and September, 1928, when both the plate-growing bacteria and *B. coli* showed an increase in average numbers in the prechlorinated water passing through filter A. As this observed increase occurred only during the period of heavy prechlorination, it can be accounted for only as being due to a marked disturbance in the normal efficiency of filtration resulting from contact of the filter with water containing relatively high amounts of residual chlorine. During the following month, October, the efficiency of this filter was regained, to a considerable extent, in spite of the continued high residual chlorine in the applied water, possibly owing to the adjustment of the filter to a condition of increased tolerance for water of high chlorine content. The behavior of this filter prior to and during the period indicated afforded evidence that the bacterial efficiency of rapid sand filters is intimately associated with biological conditions prevailing in the filtering medium. Particularly significant in this connection was the marked increase in the *B. coli* content of the effluent of filter A during August, the first month of heavy prechlorination, both as compared with the corresponding numbers of this class of organisms observed in the

TABLE 1

Monthly average numbers of bacteria and amounts of residual chlorine observed at various stages of treatment, with and without raw water prechlorination

A = raw water prechlorinated; B = raw water not prechlorinated

MONTH	AVERAGE BACTERIAL COUNT PER CUBIC CENTIMETER, 24 HOURS, 37°C.							AVERAGE B. COLI INDEX PER 100 CC.							AVERAGE RESIDUAL Cl, P.P.M.		
	Raw	Applied		Filtered		Postchlorinated		Raw	Applied		Filtered		Postchlorinated		Applied, A	Postchlorinated	
		A	B	A	B	A	B		A	B	A	B	A	B		A	B
1927																	
July	16,700	201	2,960	150	265			28,000	206	7,020	20	212					
August	16,200	518	2,580	166	235			35,000	387	3,710	28	113					
September	37,600	588	10,400	252	646	66	116	52,500	1,100	22,200	50	417	5.2	13	0.06	0.04	0.04
October	17,800	188	6,560	118	313	39	43	49,400	471	8,770	29	251	2.2	10	0.07	0.05	0.02
November	6,960	130	1,230	5.9	32	3.8	8.6	26,500	325	4,240	6.5	18	2.7	3.3	0.02	0.05	0.05
December	6,060	122	389	0.8	17.6	0.6	3.2	16,100	12	1,190	0.5	5.3	0.0	0.1	0.02	0.03	0.04
1928																	
January	1,960	78	139	1.5	0.8	0.5	0.4	23,000	70	922	0.2	2.7	0.0	0.5	0.01	0.05	0.05
February	1,410	77	171	1.4	6.0	0.8	0.8	12,400	17	1,310	0.4	38	0.2	0.5	0.02	0.05	0.05
March	1,070	61	164	0.6	2.2	0.4	0.5	16,600	64	1,870	2.2	14	0.1	0.8	0.02	0.06	0.05
April	1,690	63	147	0.3	1.6	0.03	0.07	11,500	44	1,060	0.1	5.1	0.6	0.2	0.02	0.06	0.05
May	1,730	61	414	5.8	21.5	0.3	0.4	18,700	56	2,800	1.0	55	0.6	2.4	0.03	0.05	0.05
June	5,360	95	374	9.7	22.1	1.4	2	28,800	148	3,190	4.2	36	0.3	2.1	0.02	0.04	0.04
July	6,870	27	629	24	115	14	15	36,500	39	1,600	0.6	130	0.6	1.1	0.07	0.06	0.04
August	10,400	1.9	1,310	24	171	15	11	36,000	0.3	3,390	3.3	84	2.5	3.7	0.36	0.06	0.05
September	10,600	0.5	2,000	9.9	150	8.6	2.4	43,200	0.2	8,690	0.4	80	1.1	0.5	0.77	0.08	0.06
October	18,700	12.2	6,760	3.6	680	4.1	1.9	53,500	1.5	29,500	0.2	394	0.4	4.4	0.33	0.08	0.06

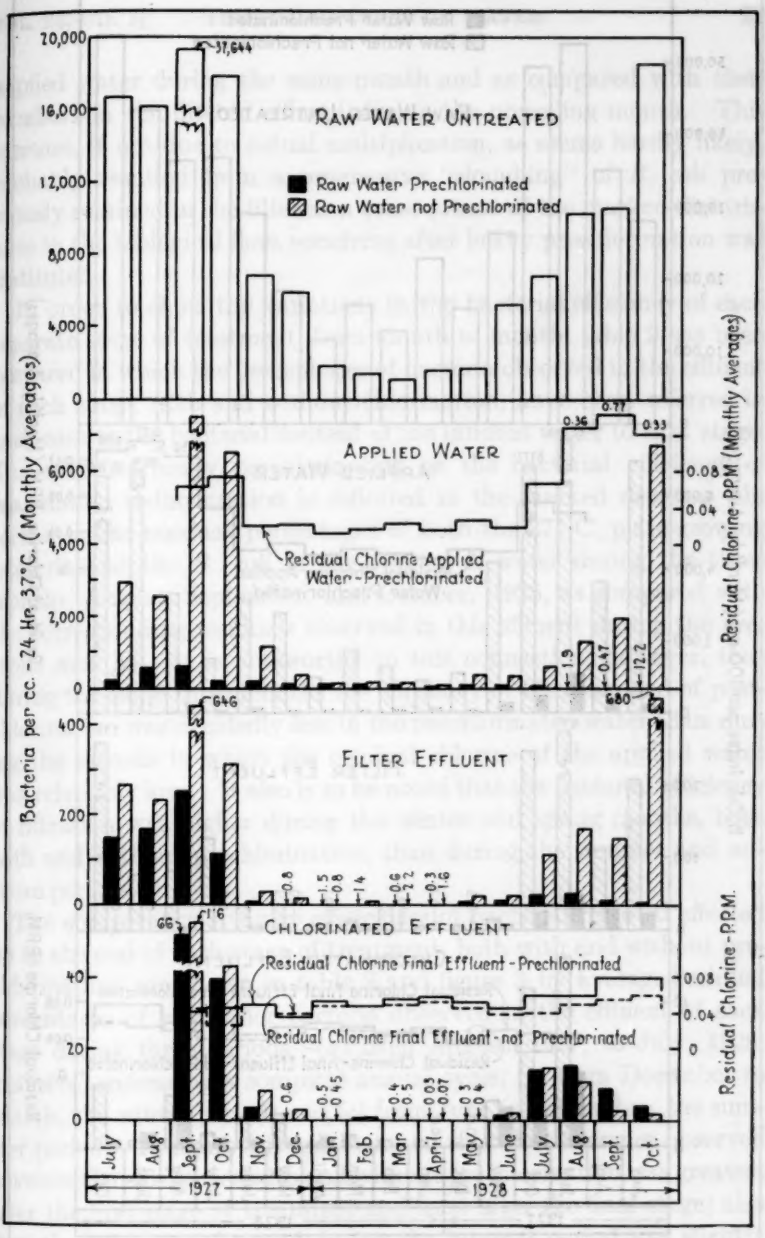

FIG. 1. COMPARATIVE MONTHLY AVERAGE BACTERIAL COUNTS, 24 HOURS AT 37° C. OBSERVED AT SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, DURING THE PERIOD OF THE EXPERIMENTS
(Based on data given in table 1)

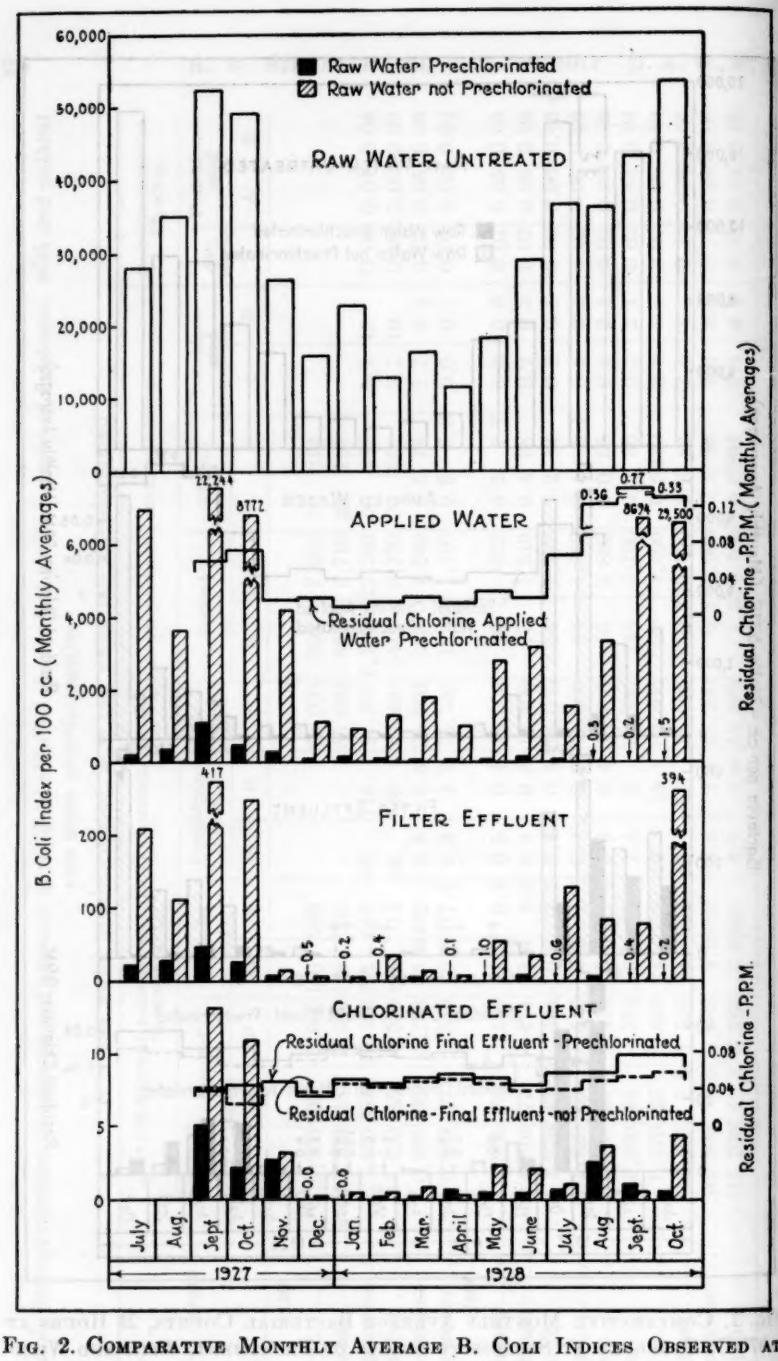

FIG. 2. COMPARATIVE MONTHLY AVERAGE B. COLI INDICES OBSERVED AT SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, DURING THE PERIOD OF THE EXPERIMENTS

(Based on data given in table 1)

applied water during the same month and as compared with their numbers in the filtered effluent during the preceding month. This increase, if not due to actual multiplication, as seems hardly likely, probably resulted from a progressive "sloughing" of *B. coli* previously retained in the filter as a consequence of the marked disturbance in the biological flora occurring after heavy prechlorination was instituted.

In order to show the variations in the bacterial efficiency of each separate stage of treatment, from month to month, table 2 has been prepared in which the percentages of bacteria observed in the effluent of each stage, with and without chlorination, have been referred in each case to the bacterial content of the influent water to that stage. The effect of heavy prechlorination on the bacterial efficiency of coagulation sedimentation is reflected in the marked decrease observed in the residual percentages of both the 37° C. plate-growing bacteria and the *B. coli* in the applied A water during the three months, August, September, and October, 1928, as compared with the corresponding residuals observed in this effluent during the previous months. It is noteworthy in this connection, however, that during the same three months the efficiency of filtration and of postchlorination was decidedly less in the prechlorinated water than during the months in which the residual chlorine of the applied water was relatively low. It also is to be noted that the bacterial efficiency of filtration was higher during the winter and spring months, both with and without prechlorination, than during the summer and autumn periods.

The comparative average efficiencies of bacterial removal effected up to the end of each stage of treatment, both with and without prechlorination, are shown in table 3 and figure 3 by average residual percentages of raw water bacteria observed in the effluent of each stage during three periods—(*a*) from August, 1927, to July, 1928, inclusive, embracing a complete annual cycle; (*b*) from December to March, the winter period; and (*c*) from June to September, the summer period. In figure 3 it will be noted that the difference observed between the efficiencies with and without prechlorination was greatest after the first stage of treatment and least after the final stage; also that the efficiency observed during the summer period was slightly less and during the winter period slightly greater, than the annual average.

In figure 4 corresponding plots covering the same periods have

TABLE 2

Percentages of the numbers of bacteria observed in the influent water of each stage of treatment remaining in the effluent of that stage (based on monthly averages given in table 1)

A = raw water prechlorinated; B = raw water not prechlorinated

MONTH	RAW WATER BACTERIAL COUNT 24 HOURS, 37°C.	PER CENT OF INFLUENT WATER BACTERIA REMAINING IN—						RAW WATER B. COLI INDEX PER 100 CC.	PER CENT OF INFLUENT WATER B. COLI REMAINING IN—					
		Applied		Filtered		Postchlorinated			Applied		Filtered		Postchlorinated	
		A	B	A	B	A	B		A	B	A	B	A	B
1927														
July	16,700	1.2	17.7	74.7	9.0			28,000	0.4	25.1	9.7	3.0		
August	16,200	3.2	15.9	32.1	9.1			35,000	1.1	10.6	7.2	3.0		
September	37,600	1.6	27.7	42.8	6.2	25.2	18.0	52,500	2.1	42.3	4.5	1.9	10.4	3.1
October	17,800	1.1	36.9	56.0	4.8	33.0	13.7	49,400	1.0	17.8	6.2	2.9	5.6	4.0
November	6,960	1.9	17.7	4.5	2.6	64.4	26.9	26,500	1.2	16.0	2.0	0.4	41.6	18.3
December	6,060	2.0	6.4	0.7	4.6	75.0	17.8	16,100	0.07	7.4	4.2	0.4	0.0	1.9
1928														
January	1,960	4.0	7.1	1.9	0.6	33.3	50.0	23,000	0.3	4.0	0.3	0.3	0.0	18.5
February	1,410	5.5	12.1	1.8	3.5	57.2	13.3	12,400	0.1	10.6	2.4	2.9	50.0	1.3
March	1,070	5.7	15.3	1.0	1.3	66.7	22.8	16,600	0.4	10.3	3.4	0.8	4.6	5.7
April	1,690	3.7	8.7	0.5	1.1	10.0	4.4	11,500	0.4	9.2	0.2	0.5	100+	3.9
May	1,730	3.5	23.9	9.5	5.3	0.5	1.8	18,700	0.3	15.0	1.8	2.0	60.0	4.4
June	5,360	1.8	7.0	10.2	5.9	14.4	9.1	28,800	0.5	11.1	2.8	1.1	7.2	5.9
July	6,870	0.4	9.2	88.9	18.3	58.3	13.1	36,500	0.1	4.4	1.5	8.1	100+	0.8
August	10,400	0.02	12.6	100+	13.1	62.5	6.4	36,000	0.008	9.4	100+	2.5	75.9	4.4
September	10,600	0.005	18.9	100+	7.5	86.9	1.6	43,200	0.005	21.0	100+	9.2	100+	0.6
October	18,700	0.06	36.2	29.5	10.0	100+	0.3	53,500	0.03	55.2	13.3	1.3	100+	1.1

been made of the residual percentages of the bacterial numbers in the influent water of each separate stage of treatment observed in the effluent of that stage, thus giving a measure of the comparative efficiency of each stage with and without prechlorination. In this chart it is noted that the average efficiency of bacterial removal by filtration and by postchlorination, respectively, was consistently less in the prechlorinated water than in that which was not prechlorinated, thus indicating that the very marked effect of prechlorination shown at the primary stage of treatment was offset in part by the diminished efficiency of filtration and postchlorination, in comparison with the efficiency observed at these two stages in the absence of prechlorination. That this result was due, in part at least, to the effect of prechlorination rather than wholly to the reduced density of bacteria in the prechlorinated water, was indicated as will be shown at a later point in this text, by the lower efficiency observed at these two stages with approximately the same numbers of bacteria in the influent water.

Effect of prechlorination on relations between quality of raw water and corresponding quality of effluents. The effect of prechlorination on the relationships observed between the bacterial quality of the raw water and the corresponding quality of the effluents from successive stages of treatment is illustrated in figures 5 and 6, which have been plotted from averages as given in table 4, obtained by grouping the daily results according to the numbers of raw water bacteria falling within various ranges of ascending magnitude and averaging, for each group, the numbers observed simultaneously in the raw water and in the effluent of each stage of treatment.

In these charts it will be noted that in both the prechlorinated and nonprechlorinated waters a consistent increase in bacterial content was shown to occur in the effluent of each stage of treatment coincidently with an increase in the numbers of raw water bacteria, though the proportionate extent of increase was measurably less in the prechlorinated water than in that which was not prechlorinated.

When the same group averages were plotted against the corresponding raw water averages on logarithmic scales, a series of plots was obtained such as are shown in figure 7, which is based on the *B. coli* group averages given in table 4 and shown in block diagram in figure 6. In figure 7 the plots designated as "A" refer to the effluents obtained from the prechlorinated water and those designated as "B" to the corresponding effluents of the non-prechlorination

TABLE 3

Comparative averages of bacterial results observed with and without raw water prechlorination, with corresponding residuals, expressed as percentages of raw and of influent water contents, respectively

A = raw water prechlorinated; B = raw water not prechlorinated

		YEARLY AVERAGE (AUG.–JULY)		WINTER (DEC.–MAR.)		SUMMER (JUNE–SEPT.)	
		A	B	A	B	A	B
Bacterial Count, 24 hours, 37°C.							
	Raw	8,730		2,170		14,600	
Per cubic centimeter	Applied	167	1,930	80	202	330	3,050
	Filtered	49	118	1.1	6.1	121	226
	Postchlorinated	12	17	0.6	1.1	21	36
Per cent of raw water count	Applied	1.9	22.1	3.7	9.3	2.3	20.9
	Filtered	0.56	1.35	0.05	0.28	0.83	1.6
	Postchlorinated	0.14	0.19	0.03	0.05	0.14	0.24
Per cent of influent water count	Applied	1.9	22.1	3.7	9.3	2.3	20.9
	Filtered	29.4	6.1	1.4	3.0	36.7	7.4
	Postchlorinated	24.5	14.4	54.5	17.4	25.1	17.2

		B. coli index					
	Raw	27,200		15,500		34,500	
Per 100 cubic centimeters	Applied	228	4,410	36	1,420	372	6,800
	Filtered	10	96	0.94	21	22	150
	Postchlorinated	1.1	3.1	0.10	0.48	1.9	5.8
Per cent of raw water index	Applied	0.84	15.9	0.23	9.1	1.1	19.7
	Filtered	0.037	0.345	0.006	0.14	0.064	0.44
	Postchlorinated	0.004	0.011	0.0006	0.0031	0.0052	0.0158
Per cent of influent water index	Applied	0.84	15.9	0.23	9.1	1.1	19.7
	Filtered	4.4	2.2	2.6	1.5	5.9	2.2
	Postchlorinated	11.0	3.2	10.4	2.3	9.8	4.1

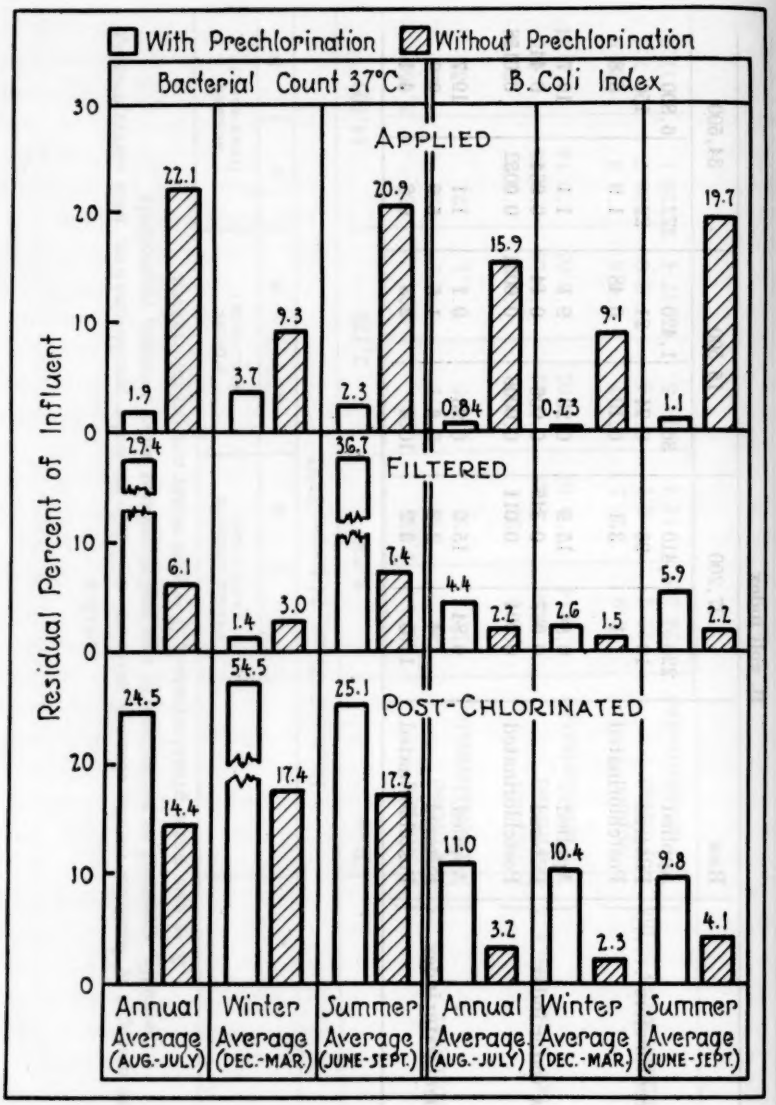

FIG. 3. COMPARATIVE RESIDUAL PERCENTAGES OF RAW WATER BACTERIA OBSERVED IN EFFLUENTS OF SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, UNDER ANNUAL, WINTER AND SUMMER AVERAGE CONDITIONS

(Based on data given in table 3)

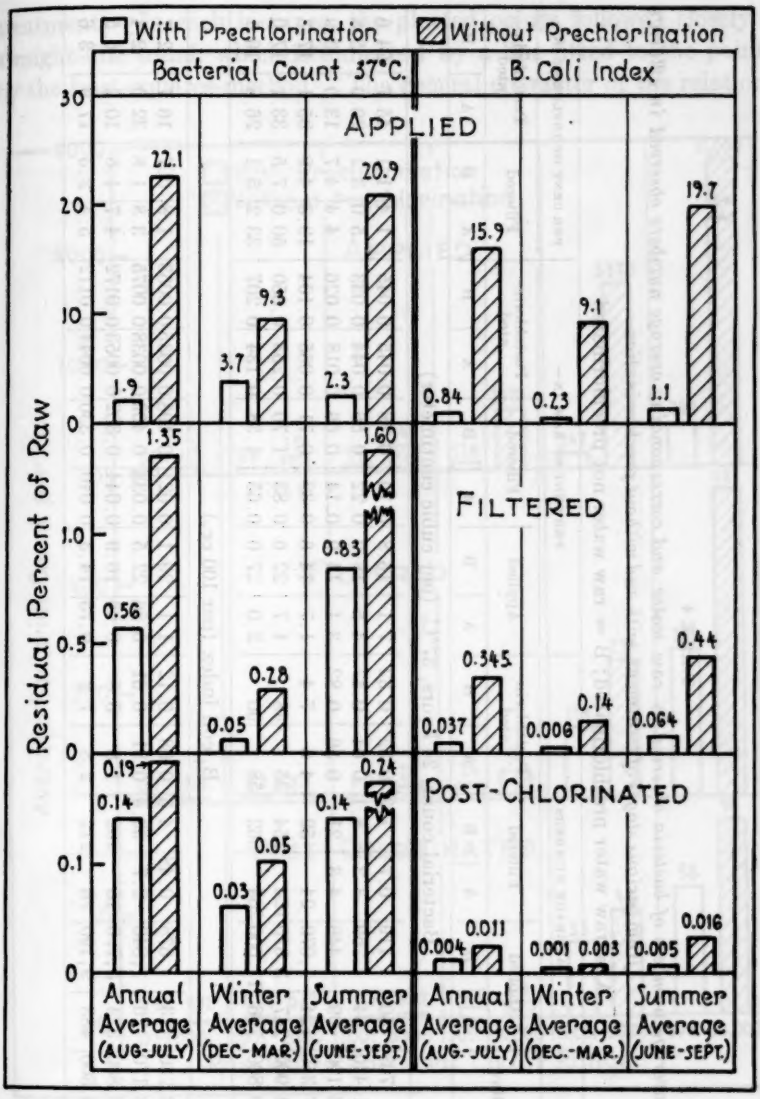

FIG. 4. COMPARATIVE RESIDUAL PERCENTAGES OF INFLUENT WATER BACTERIA OBSERVED IN EFFLUENTS OF SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, UNDER ANNUAL, WINTER AND SUMMER AVERAGE CONDITIONS

(Based on data given in table 3)

TABLE 4

Relations between average numbers of bacteria observed in raw water and corresponding average numbers observed in effluents from various stages of treatment, with and without prechlorination

A = raw water prechlorinated; B = raw water not prechlorinated

RAW WATER RANGE	AVERAGE NUMBERS							PER CENT OF RAW IN—						PER CENT OF INFLUENT IN—			
	Raw	Applied		Filtered		Postchlorinated		Applied		Filtered		Postchlorinated		Filtered		Postchlorinated	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Bacterial count, 24 hours, 37°C. (per cubic centimeter)																	
0– 1,000	708	50	119	0.7	1.3	0.32	0.32	7.1	16.8	0.10	0.18	0.045	0.045	1.4	1.1	45.7	24.6
1,001– 2,000	1,440	64	259	3.2	8.1	0.64	0.47	4.5	18.0	0.22	0.56	0.044	0.033	5.0	3.1	20.0	5.8
2,001– 5,000	3,190	99	448	4.3	21	0.56	0.82	3.1	14.0	0.14	0.66	0.018	0.026	4.4	4.7	13.0	3.9
5,001–10,000	7,350	124	1,070	24	52	4.6	7.4	1.7	14.6	0.32	0.71	0.065	0.104	19.3	4.9	35.1	17.3
10,001–25,000	14,900	247	3,370	124	254	35	48	1.7	22.6	0.83	1.70	0.253	0.350	50.0	7.5	33.1	17.0
Over 25,000	40,800	796	11,000	264	562	58	90	2.0	27.0	0.65	1.38	0.134	0.207	33.2	5.1	26.8	16.1
B. coli index (per 100 cc.)																	
1– 5,000	2,280	23	678	0.48	4.5	0.08	0.12	1.1	29.1	0.021	0.198	0.0035	0.0053	1.8	0.7	16.7	2.7
5,001–10,000	8,170	70	1,840	2.7	33.4	0.31	0.61	0.86	22.5	0.033	0.409	0.0038	0.0075	3.8	1.8	32.0	2.4
10,001–50,000	33,800	324	5,720	15	102	1.8	5.8	0.96	16.9	0.044	0.302	0.0053	0.0172	4.7	1.8	10.2	6.5
Over 50,000	64,300	483	9,190	26	212	2.8	7.2	0.75	14.3	0.040	0.330	0.0044	0.0112	5.4	2.3	17.9	3.6

treatment. In each instance, the plotted points followed closely a straight-line trend, which is indicated by a line fitted to the points by the least-squares-method The general character of the relation-

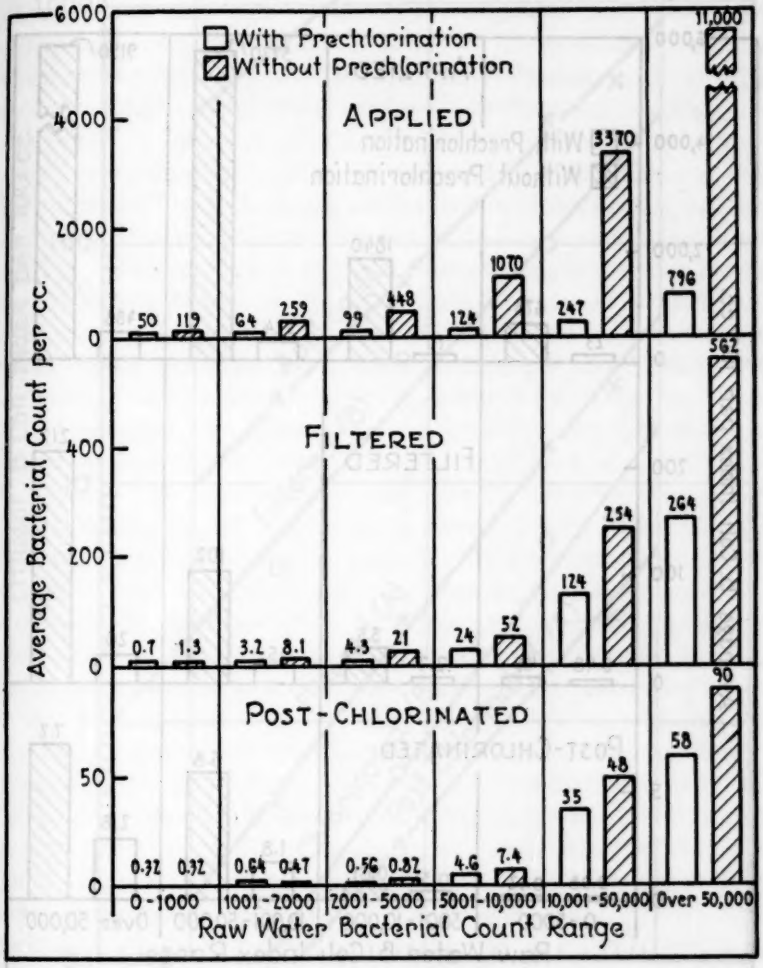

FIG. 5. COMPARATIVE AVERAGE NUMBERS OF PLATE-GROWING BACTERIA 24 HOURS AT 37 C., OBSERVED IN EFFLUENTS OF SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, CORRESPONDING TO AVERAGES OF NUMBERS OF RAW WATER BACTERIA FALLING WITHIN VARIOUS SPECIFIED RANGES

(Based on data given in table 4)

ships thus shown was the same as previously observed, both experimentally and at full-scale municipal plants, between the bacterial quality of raw waters as delivered for treatment and that of the effluents produced from them at various stages of treatment.[10]

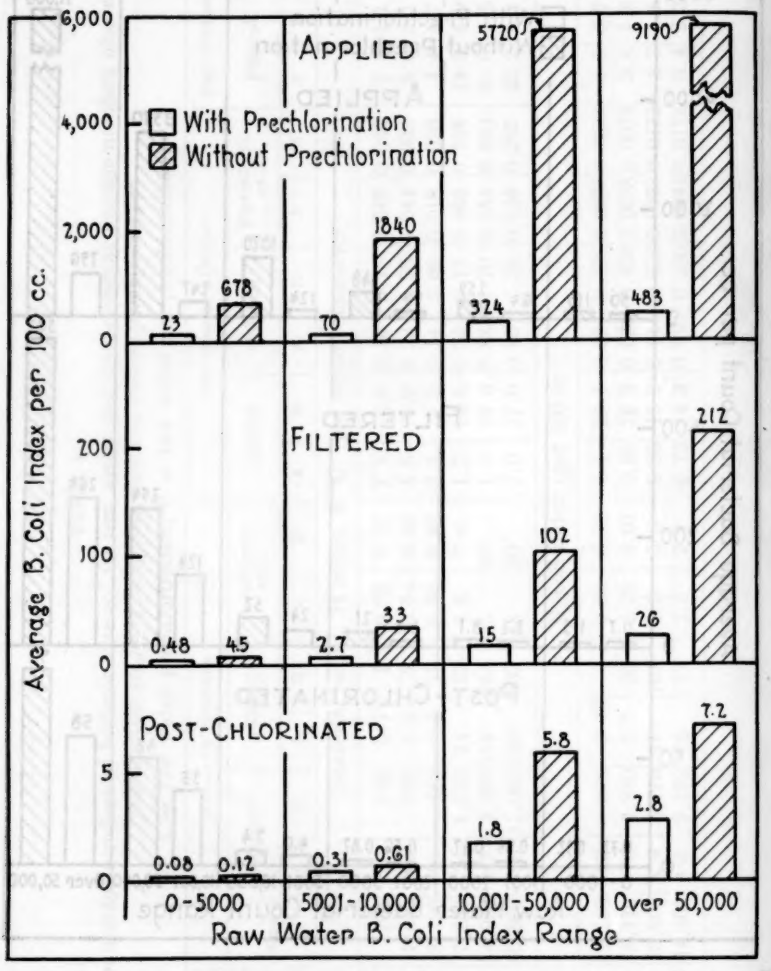

FIG. 6. COMPARATIVE AVERAGE NUMBERS OF B. COLI OBSERVED IN EFFLUENTS OF SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION, CORRESPONDING TO AVERAGES OF NUMBERS OF RAW WATER B. COLI FALLING WITHIN VARIOUS SPECIFIED RANGES

(Based on data given in table 4)

[10] See Public Health Bulletins Nos. 172 and 193.

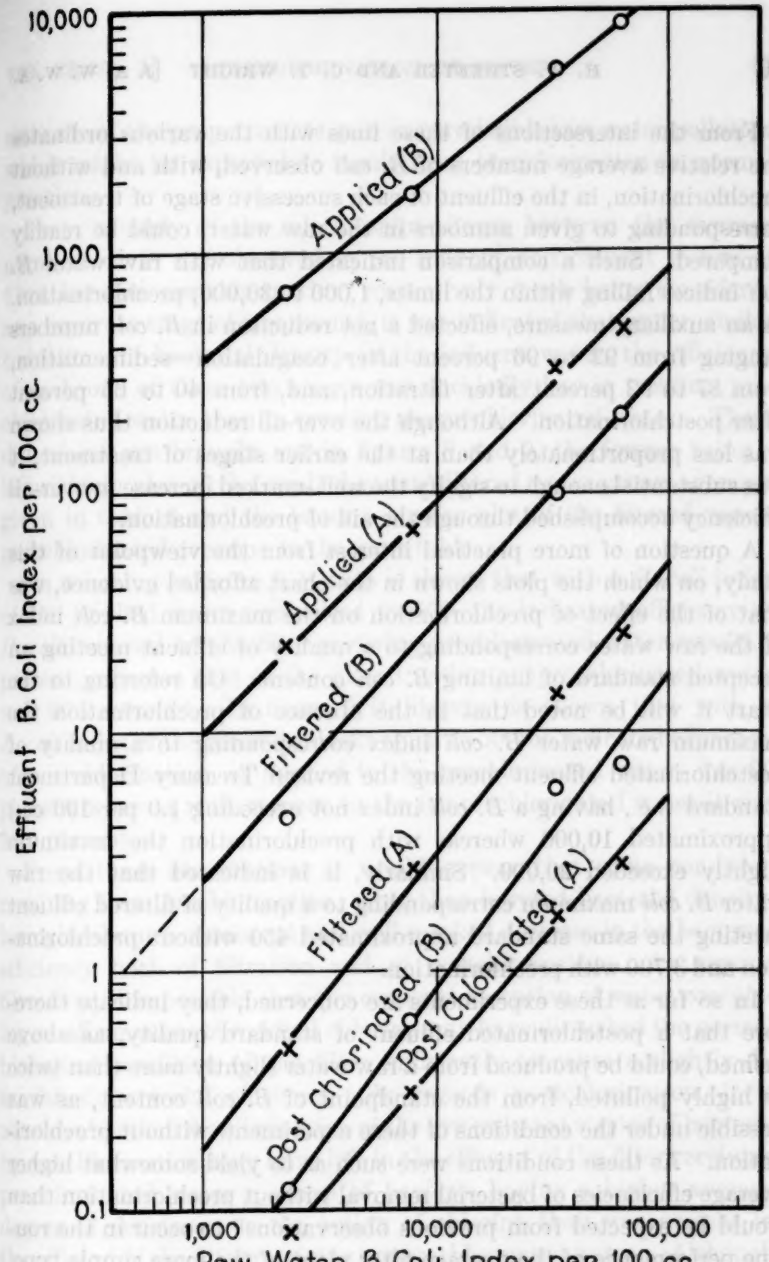

FIG. 7. LOGARITHMIC PLOT SHOWING COMPARATIVE RELATIONS OBSERVED BETWEEN AVERAGES OF NUMBERS OF RAW WATER B. COLI FALLING WITHIN VARIOUS RANGES AND CORRESPONDING NUMBERS IN EFFLUENTS OF SUCCESSIVE STAGES OF TREATMENT, WITH AND WITHOUT PRECHLORINATION
(Based on data given in table 4)

From the intersections of these lines with the various ordinates the relative average numbers of *B. coli* observed, with and without prechlorination, in the effluent of each successive stage of treatment, corresponding to given numbers in the raw water, could be readily compared. Such a comparison indicated that with raw water *B. coli* indices falling within the limits, 1,000 to 30,000, prechlorination, as an auxiliary measure, effected a net reduction in *B. coli* numbers ranging from 92 to 96 percent after coagulation—sedimentation, from 87 to 92 percent after filtration, and, from 40 to 65 percent after postchlorination. Although the over-all reduction thus shown was less proportionately than at the earlier stages of treatment, it was substantial enough to signify the well-marked increase in over-all efficiency accomplished through the aid of prechlorination.

A question of more practical interest from the viewpoint of this study, on which the plots shown in the chart afforded evidence, was that of the effect of prechlorination on the maximum *B. coli* index of the raw water corresponding to a quality of effluent meeting an accepted standard of limiting *B. coli* content. On referring to the chart it will be noted that in the absence of prechlorination the maximum raw water *B. coli* index corresponding to a quality of postchlorinated effluent meeting the revised Treasury Department standard (i.e., having a *B. coli* index not exceeding 1.0 per 100 cc.) approximated 10,000 whereas with prechlorination the maximum slightly exceeded 20,000. Similarly, it is indicated that the raw water *B. coli* maximum corresponding to a quality of filtered effluent meeting the same standard approximated 450 without prechlorination and 3,700 with prechlorination.

In so far as these experiments are concerned, they indicate therefore that a postchlorinated effluent of standard quality, as above defined, could be produced from a raw water slightly more than twice as highly polluted, from the standpoint of *B. coli* content, as was possible under the conditions of these experiments without prechlorination. As these conditions were such as to yield somewhat higher average efficiencies of bacterial removal without prechlorination than would be expected from previous observations[11] to occur in the routine performance of the average filter plant of the more simple type, the foregoing statement probably represents a fairly conservative

[11] See Public Health Bulletins Nos. 172 (p. 173) and 193 (p. 86); also Reprint No. 1114 from the Public Health Reports (p. 24).

estimate of the proportionate gain in permissible raw water pollution which might be expected to result from prechlorination in normal practice.

From a study of the relationships shown between the average numbers of *B. coli* observed in the influent and effluent waters of filtration and postchlorination, respectively (each being considered as a separate stage of treatment), it was indicated that under similar conditions of bacterial density in the influent water, the efficiency of each one of these two stages was decidedly less in treating prechlorinated water than in treating nonprechlorinated water. These differences are brought out in figures 8 and 9, the former being a logarithmic plot of the applied versus filtered water group averages given in table 4 and the latter a similar plot of the filtered versus postchlorinated averages in the same table.

On referring to figure 8, it thus is shown that with a *B. coli* index of the applied water equivalent to 500, the indicated efficiency of *B. coli* removal by the filter receiving prechlorinated water was 94.6 percent, whereas that of the filter treating nonprechlorinated water was 99.2 percent. In figure 9 it likewise is shown that with a *B. coli* index of the filtered effluent equal to 50, the indicated efficiency of postchlorination, as applied to the prechlorinated water, was 90 percent whereas with respect to the nonprechlorinated water it was 96.6 percent.

From these observations it would appear that some condition resulting from prechlorination, other than lowered bacterial density, brought about a consistent and well-marked decrease in the bacterial efficiency both of filtration and of postchlorination. As regards filtration, it is possible that the constant reception of water containing small amounts of residual chlorine may have disturbed the normal biological condition of the filter sufficiently to cause a slightly diminished bacterial efficiency. As regards postchlorination, it is conceivable that the elimination of the less resistant strains of bacteria by prechlorination may have left in the effluent of the filter receiving prechlorinated water a group of bacteria having a higher average degree of resistance to the action of chlorine than was present in the effluent of the filter receiving nonprechlorinated water. Although the true reasons for the phenomena observed must remain, for the present at least, unexplained, the significance of these phenomena is fairly evident. In so far as any generalized conclusion may be drawn from these observations, it would seem to be that where raw water

prechlorination is practiced regularly and continuously, a certain degree of impairment in the normal bacterial efficiency of filtration and of postchlorination may be expected to occur. From a practical standpoint such impairment may not be highly important, con-

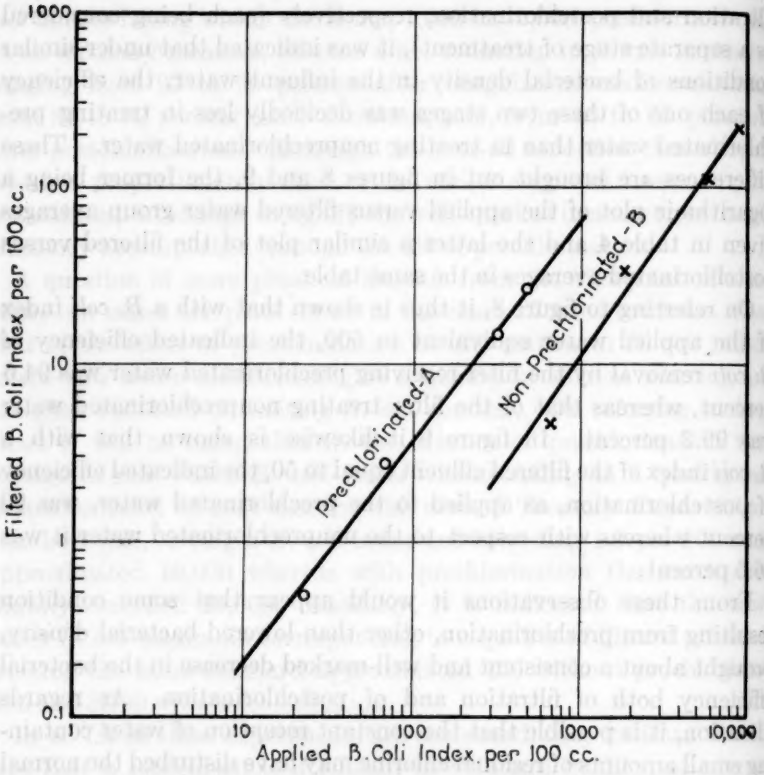

FIG. 8. COMPARATIVE RELATIONS OBSERVED BETWEEN B. COLI INDEX OF WATER APPLIED TO FILTERS RECEIVING PRECHLORINATED AND NON-PRECHLORINATED WATERS, RESPECTIVELY, AND CORRESPONDING B. COLI INDEX OF UNCHLORINATED EFFLUENTS OF THESE FILTERS

(Based on data given in table 4)

sidering the extent to which it appears to be offset by the effect of prechlorination.

Supplementary observations.—In addition to tests concerned with the effect of prechlorination on the efficiency of bacterial removal, supplementary observations were made, during the course of the

experiments, on certain other aspects of the problem, notably the following:

1. The effect of prechlorination on the development of microscopic organisms in the sedimentation basin and filter.

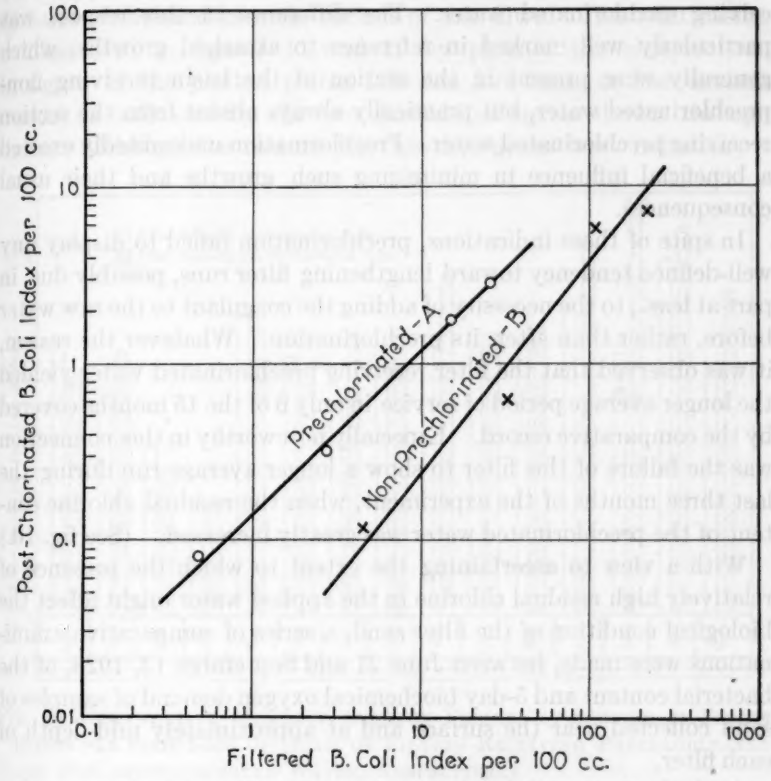

FIG. 9. COMPARATIVE RELATIONS OBSERVED BETWEEN B. COLI INDEX OF UNCHLORINATED EFFLUENTS OF FILTERS RECEIVING PRECHLORINATED AND NON-PRECHLORINATED WATERS, RESPECTIVELY, AND CORRESPONDING B. COLI INDEX OF THE SAME EFFLUENTS AFTER POST-CHLORINATION

(Based on data given in table 4)

2. The influence of prechlorination on the length of filter run.

3. The effects of residual chlorine in the applied water on the biological condition of the filter sand.

4. The comparative performances of the plant with relatively low and high chlorine residuals in the prechlorinated water.

Although growths of microscopic organisms developed in the water on only a few brief occasions with sufficient intensity to cause perceptible effects on the operation of the plant, the section of the basin receiving prechlorinated water was noticeably freer from such growths throughout the course of the experiments than was the section receiving unchlorinated water. The difference in this respect was particularly well marked in reference to attached growths, which generally were present in the section of the basin receiving non-prechlorinated water, but practically always absent from the section receiving prechlorinated water. Prechlorination undoubtedly exerted a beneficial influence in minimizing such growths and their usual consequences.

In spite of these indications, prechlorination failed to display any well-defined tendency toward lengthening filter runs, possibly due, in part at least, to the necessity of adding the coagulant to the raw water before, rather than after, its prechlorination. Whatever the reason, it was observed that the filter receiving prechlorinated water yielded the longer average period of service in only 6 of the 15 months covered by the comparative record. Especially noteworthy in this connection was the failure of this filter to show a longer average run during the last three months of the experiment, when the residual chlorine content of the prechlorinated water was greatly increased. (See fig. 10.)

With a view to ascertaining the extent to which the presence of relatively high residual chlorine in the applied water might affect the biological condition of the filter sand, a series of comparative examinations were made, between June 21 and September 13, 1928, of the bacterial content and 5-day biochemical oxygen demand of samples of sand collected near the surface and at approximately mid-depth of each filter.

At the beginning of the observations, when filter A had been receiving for about a year, prechlorinated water carrying a residual chlorine of 0.02 to 0.05 p.p.m., the bacterial content of the sand in the upper strata of this filter was found to be about 10 percent of that of the sand in filter B receiving unchlorinated water. As the residual chlorine in the water applied to filter A was increased, this ratio became progressively diminished. At the end of the period, when the residual chlorine of the water applied to filter A had reached about 0.8 p.p.m. the upper strata of this filter contained fewer plate-growing bacteria and were practically free of *B. coli*. The lower strata still

yielded considerable numbers of bacteria at this time, though they were somewhat lower than in filter B.

In the foregoing connection it is of interest to note the fairly definite relationship observed between the residual chlorine content of the water applied to filter A and both the bacterial content and oxygen demand of the sand near the surface of this filter. This relationship is illustrated in figures 11 and 12 by plots of the observations. In figure 11 the plotted points followed two more or less distinct trends, as indicated by the two dashed-line curves drawn through them. Although the reasons for this divergence were not clear, it

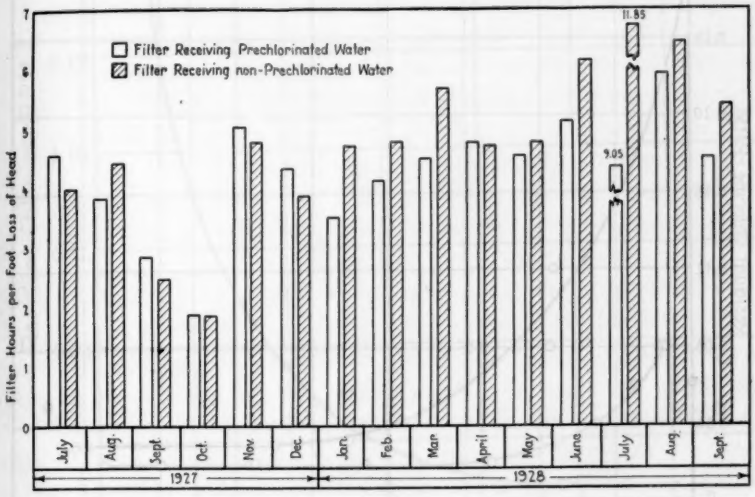

FIG. 10. COMPARATIVE MONTHLY AVERAGE PERIODS OF SERVICE, IN FILTER HOURS PER FOOT LOSS OF HEAD, OF FILTERS RECEIVING PRECHLORINATED AND NON-PRECHLORINATED WATER, RESPECTIVELY

appears to have been associated with differences in the action of chlorine in the bacterial flora of the filter during the earlier and later portions, respectively, of the test period. No similar divergence was observed in the oxygen demand plots in figure 12.

Throughout the period of heavy prechlorination the numbers of bacteria and the biochemical oxygen demand of the sand near the surface of filter A were very considerably less than in the lower strata, indicating that a large proportion of the chlorine absorption by the filter sand occurred in the upper strata. The extent of this absorption may be illustrated by noting that during a period of five weeks,

when the residual chlorine content of the applied water averaged 0.76 p.p.m., the corresponding residual in the filtered effluent averaged 0.01 p.p.m., the estimated amount of chlorine absorbed by the filter being, by difference, 0.75 mg. per liter of water filtered, or about 0.4 pound per square foot of filter surface.

Although the major portion of the chlorine thus absorbed appears to have been consumed by the organic matter lodged in the filtering medium, a small part of it seemingly was stored in the filter in its free

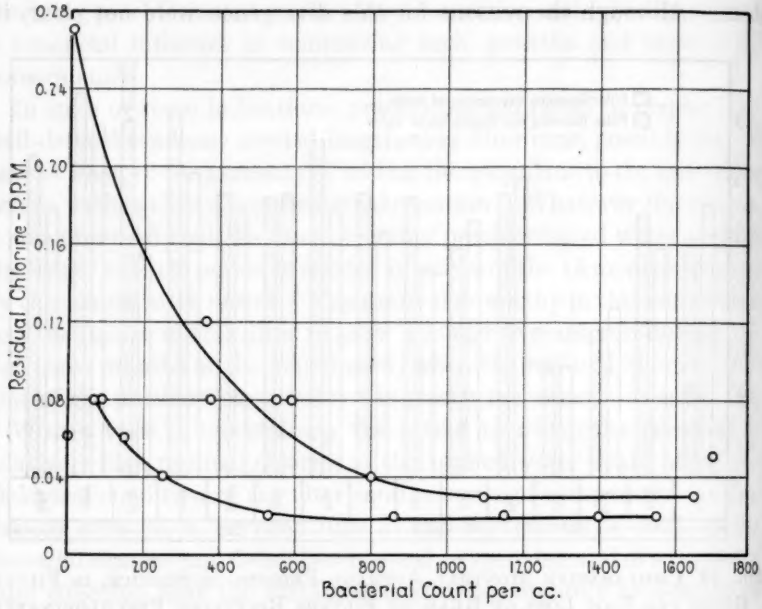

FIG. 11. RELATION OBSERVED BETWEEN RESIDUAL CHLORINE CONTENT OF WATER APPLIED TO FILTER "A" AND BACTERIAL CONTENT OF SAMPLES OF SAND COLLECTED FROM THE UPPER STRATUM OF THIS FILTER

state, as was evidenced by the distinct lag, extending over a period of two weeks, observed in the rate of decrease in the residual chlorine of the filtered effluent following a sharp reduction in the chlorine content of the applied water to less than 0.2 p.p.m.

Perhaps the most significant feature of these observations, however, was the persistence of bacterial life in filter A during the 10 weeks of heavy prechlorination, when the residual chlorine content of the applied water averaged 0.6 p.p.m. and ranged as high as 1.2 p.p.m.

The only reasonable explanation which can be offered for this phenomenon was that the heavy absorption of chlorine occurring in the upper part of the filter probably reduced the residual chlorine in the water passing through the filter to such an extent that its bactericidal action was lost when it had reached the lower strata.

The data from the entire series of experiments, extending over 16

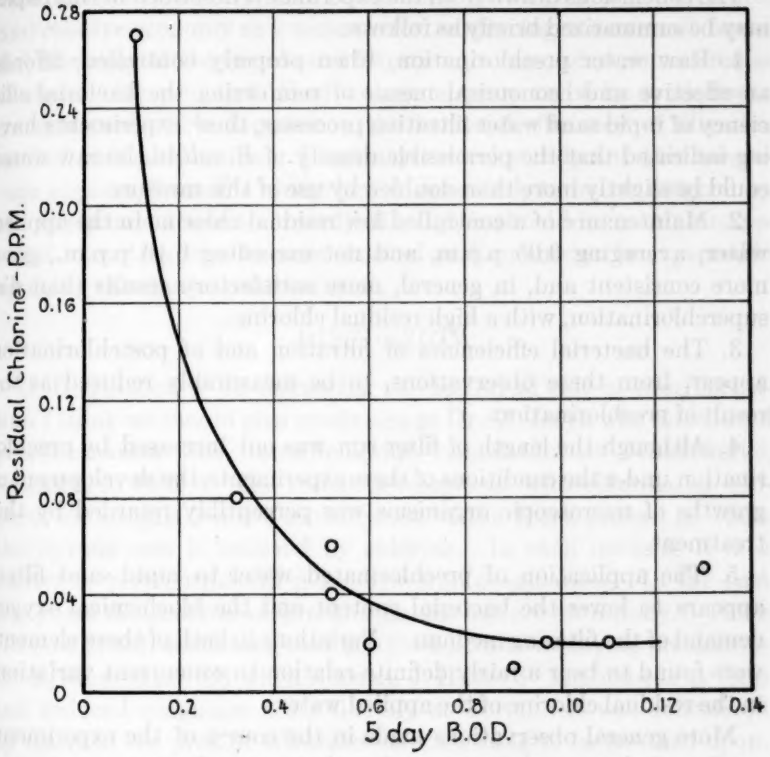

FIG. 12. RELATION OBSERVED BETWEEN RESIDUAL CHLORINE CONTENT OF WATER APPLIED TO FILTER "A" AND 5-DAY BIOCHEMICAL OXYGEN DEMAND OF SAMPLES OF SAND COLLECTED FROM THE UPPER STRATUM OF THIS FILTER

months, indicated that more consistent and, on the whole, more effective results were obtained from carefully controlled prechlorination of the raw water to a degree such as to maintain a low residual chlorine content of the applied water, averaging about 0.05 p.p.m. and not exceeding 0.1 p.p.m. during short periods. Heavy prechlorination, to the extent carried during the last three months of the period, gave

a higher degree of bacterial reduction through the preliminary basin treatment than did simple prechlorination, but exerted a marked disturbing effect on the efficiency of filtration, which was less apparent when a water of low residual chlorine was applied to the same filter.

CONCLUSIONS

The conclusions drawn from the experiments described in this paper may be summarized briefly as follows:

1. Raw water prechlorination, when properly controlled, affords an effective and economical means of reinforcing the bacterial efficiency of rapid sand water filtration processes, these experiments having indicated that the permissible density of *B. coli* in the raw water could be slightly more than doubled by use of this measure.

2. Maintenance of a controlled low residual chlorine in the applied water, averaging 0.05 p.p.m. and not exceeding 0.10 p.p.m., gave more consistent and, in general, more satisfactory results than did superchlorination, with a high residual chlorine.

3. The bacterial efficiencies of filtration and of postchlorination appear, from these observations, to be measurably reduced as the result of prechlorination.

4. Although the length of filter run was not increased by prechlorination under the conditions of these experiments, the development of growths of microscopic organisms was perceptibly retarded by this treatment.

5. The application of prechlorinated water to rapid sand filters appears to lower the bacterial content and the biochemical oxygen demand of the filtering medium. Variations in both of these elements were found to bear a fairly definite relation to concurrent variations in the residual chlorine of the applied water.

More general observations made in the course of the experiments confirmed the prevalent impression that it is advantageous to prechlorinate before, rather than after, preliminary sedimentation in order to utilize the stabilizing effect of basin treatment prior to applying prechlorinated water to filters. They also indicated, however, that even with the stabilizing influence of such basin treatment careful technical supervision and laboratory control are necessary to maintain a relatively constant chlorine content of water applied to filters, which appears to be a desirable condition for consistently effective filtration. Although the ability of well-ripened filters to absorb excessive amounts of chlorine for considerable periods of time constitutes a

valuable operating factor of safety, in so far as the production of over-chlorinated effluents is concerned, any undue burdening of filters with excessively chlorinated water may be expected, as shown in these studies, to result in a measurable impairment of their bacterial efficiency.

In conclusion, the main advantage of prechlorination, from the viewpoint of this study, may be summed up as being its effectiveness and relative economy as a measure for reinforcing the over-all bacterial efficiency of the rapid-sand filtration process, when considered as a whole. Its principal disadvantage appears to be its tendency to cause a perceptible decrease in the bacterial efficiency of filtration and of postchlorination. From a practical standpoint this advantage appears, from the study herein described, to be outweighed by the advantage above indicated, although it should be taken into account in casting up a balance sheet of performance to be expected in applying this method of treatment.

DISCUSSION

L. H. ENSLOW:[12] In discussing the historical side of prechlorination I think we should give credit also to Dr. M. Duyk who introduced prechlorination with ferric chloride coagulation at Middlekerke, Belgium, in 1902.[13] The recent development with chlorinated copperas for coagulation is a modification of the Duyk process in which the ferrous iron is oxidized by chlorine. In each instance it is a matter of prechlorination plus ferric iron coagulation. In the past few years the practice of prechlorination has grown rapidly. There are now (1930) something over 200 filter plants employing prechlorination, whereas in 1921 when Norman J. Howard[14] applied the process and reduced coagulant costs thereby at Toronto it was considered by many of the present advocates as something to be frowned upon.

Referring to Messrs. Streeter's and Wright's findings as to the filter unloading effect and lowering of efficiency caused by prechlorination, it is difficult to find by a study of the charts that the filter effluent from prechlorinated water was ever as high in total bacteria or B. coli as was the control filter effluent which was not prechlorinated.

[12] The Chlorine Institute, Inc., New York, N. Y.

[13] Geo. C. Whipple. Disinfection as a Means of Water Purification. Proc. A. W. W. A. 1906, p. 266–268; Eng. Rec., 54:94:1906.

[14] Norman J. Howard. Chlorination Prior to Filtration. Jour. A. W. W. A., 9:4:1922 Modified Prechlorination Treatment. Can. Eng., Feb. 26, 1924.

In studying the graphs it is difficult to agree that the increase in total bacteria in the prechlorinated filter effluent during July and August represents unloading. The B. coli figures do not support the unloading theory. The results after postchlorination suggest that the bacteria came through in the applied water and merely indicate that these were of a chlorine-resisting type. The long period of moderate prechlorination must have proven beneficial in preventing marked unloading such as is frequently observed at filter plants during the first stages of prechlorination, as is indicated by the Hopewell, Va., results (fig. 6).[4]

That filter beds receiving water containing residual chlorine do unload is apparent from the observed reduction of the "slime" on the sand grains at the Cincinnati plant and elsewhere. It is on this account that it is perhaps advisable before beginning prechlorination to cut one or more filter units out of service at a time and give them a heavy superchlorination treatment overnight followed by a good wash. In this manner all units may be unloaded in advance of beginning the prechlorination process. When employing prechlorination to an extent which results in higher residuals than 0.1 p.p.m. or thereabouts in the applied water one must consider the filter primarily as an efficient strainer. This, or any other term, may be applied to indicate that it is no longer a biological unit.

At Mamaroneck, N. Y., plant there is a marked difference between the cleanliness of the filter sand now as compared with what it was before beginning the use of chlorinated copperas for coagulation. The units wash excellently and are not long about it. The filter runs have increased regardless of the presence of a very fine grained sand in the beds. Prechlorination automatically goes along with the use of chlorinated copperas coagulation.[15]

Mr. Streeter mentioned the apparent property of the filter bed to store up available chlorine, and thereafter release it gradually. Some years ago I had occasion to take samples of the filter discharge from certain pressure filters practically 24 hours after the prechlorination had ceased. Much to my surprise the effluent was bacterially very satisfactory. It was my first experience with this feature of prechlorination.

One of the most significant observations made by Mr. Streeter is that which discloses the permissible filter plant loading which can be

[15] Alex. Potter and Wm. I. Klein. Ferric Iron Coagulation at Mamaroneck, N. Y. Water Works and Sewerage, Aug. 1930, p. 261.

handled without depending upon post chlorination to produce a satisfactory final effluent. Without prechlorination the limit of B. coli density in the raw water was found to be 450 per 100 cc. With prechlorination a satisfactory effluent could be had with a raw water B. coli index of 3700 per 100 cc. Surely this observation is far more important than those showing that the less the numbers of bacteria existing in the prechlorinated water applied to the filters, the lower the per cent efficiency of bacterial reduction through the filters. It is quite apparent that, if applied water contained 10 bacteria per cc. and the effluent contained only 8 bacteria per cc., the calculated filter efficiency is but 20 percent, whereas an effluent containing 800 bacteria per cc. from an applied water containing 10,000 per cc. represents an efficiency of 92 percent when we disregard the comparative safety of the two effluents. Such observations show one thing, and that is the necessity of discarding our previous measuring sticks and acceptance of the newer facts which show the non-dependence upon biological phenomena in rapid sand filters and a new measure of safety in plant performance when prechlorination can be applied.

Another significant observation which appears upon examination of the data and curves accompanying the paper is the fact that, without prechlorination, postchlorination becomes an important *integral part* of the system, whereas with prechlorination the postchlorination once considered as purely a *last line of defense* really assumes that rôle.

In a paper[4] before The Association meeting at San Francisco, Calif. (1928) illustrations were used to indicate the dependability of fixed rate prechlorination for eliminating the sporadic occurrences of high B. coli counts in the filter effluent. Since these occurrences represent more important and critical conditions than average B. coli figures do, *the reduction of the frequency of high B. coli content in the filter effluent is a more important measuring rod than the reduction of averages.* It would have been interesting to see a graph comparing the frequency of various B. coli densities in the effluent of the prechlorinated and in the control filter at the U. S. P. H. S. experiment station. In view of the fact, however, that such careful control and supervision of the experimental filter plant at Cincinnati was being maintained during the studies it is improbable that the B. coli index of the filter effluent without prechlorination was allowed to become excessive at any time and therefore a great virtue of prechlorination was never in evidence.

While Messrs. Streeter and Wright have presented their data and conclusions in a most interesting and thoroughly scientific and impartial manner, all that is needed to convince one that prechlorination is not fraught with dangers of upsetting the practical side of water purification is to examine the tables and graphs which show *actual* comparative B. coli contents of the filter effluents *during the periods when excessive residual chlorine was being carried onto the filters.* These figures are significant, whereas the efficiency data do not reveal the important features of prechlorination.

There is at least one weakness in prechlorination and it would have been well to point this out in the paper. I refer to the greater likelihood of taste production when raw water is chlorinated than when the coagulated and settled or filtered water is chlorinated. One should carefully investigate the possibility of taste troubles before beginning prechlorination. If there is likely to be trouble, the raw water can be first ammoniated before chlorine is applied, or, if preferable, some other available taste control measure such as prepared chloramine[16] should be adopted.

Concerning the note of warning which Streeter and Wright sound, to the effect that careful technical supervision of prechlorination is of importance, I should say from experience that, if there is one thing which prechlorination does accomplish it is to reduce the importance of a very careful supervision of the chlorination process *as a whole.* Prechlorination as a process is better fortified to combat sudden loads on filter plants than is postchlorination.

[16] W. Hirschkind. Chloramine—Its Preparation, Properties and Uses. Western Construction News, Oct. 25, 1930, p. 531.

EFFICIENCY OF CHLORINATION AT CHICAGO[1]

By H. H. Gerstein[2]

A study of the data obtained during five years of chlorination in Chicago, January 1, 1925, to December 31, 1929, which includes the results of bacterial analyses of over 50,000 samples of raw and chlorinated water, shows that Great Lakes water of widely varying pollution may be treated by chlorination alone to produce a safe drinking water which is well within the U. S. Treasury Department standard, provided strict supervision is maintained over the treatment at all times.

QUALITY OF RAW WATER

Chicago obtains its water supply from Lake Michigan through six intake cribs located along the lake front at distances varying from 2 to 4 miles from shore. The quality of the water at any one of these cribs, no matter how near or far from the sources of pollution, may vary within wide limits within a short period of time, from a practically sterile to a moderately or grossly polluted water, or vice versa. This condition is due to the fact that the pollution is carried by wind induced currents which vary with every change of wind direction. The most southerly intake—the Dunne Crib—being nearest to the highly polluted section of the lake off the Calumet industrial region, obviously receives the most polluted water. The quality of the water at the other intakes varies with the distance from shore and from the sources of pollution.

Table 1 is a summary of the frequency of occurrence of various degrees of pollution at the intakes. It will be noted that the frequency of the greater pollution is low. This, however, is not criterion of the difficulties encountered in the treatment of the water; the raw water may at any time, without warning, become highly polluted.

The percentage frequency of occurrence when the B. coli content of the raw water at the various intakes was equal to or greater than 10, 100 and 1000 B. coli per 100 cc. is shown in figure 1.

[1] Presented before the Water Purification Division Session, St. Louis Convention, June 5, 1930.

[2] Sanitary Engineer, Department of Public Works, Chicago, Ill.

CHLORINATION CONTROL

Since treatment with chlorine is the only line of defense in protecting the quality of its public water supply, Chicago has of necessity developed a highly organized chlorination control system. The chlorine is applied at each of the 12 pumping stations at a point before the water reaches the suction of the pumps. In order to insure continuity of operation, all the chlorination equipment is in duplicate. A man is on duty at each pumping station at all times. His sole work consists of operating chlorination apparatus, performing control tests and keeping records of these tests. Control tests consist of hourly checks on the operation of the chlorinators by determining the loss of weight of the chlorine cylinders, and hourly ortho-tolidin

TABLE 1

Percentage frequency of occurrence of B. coli in raw water at crib intakes, Chicago, Ill., 1925–1929

CRIB INTAKE	YEAR	NUMBER OF SAMPLING DAYS	PERCENTAGE FREQUENCY OF OCCURRENCE BY DAYS—B. COLI PER 100 CC.								
			0	2	4	6	8	10	100	1000	10,000
Wilson	1925–29	1,826	45.3	26.2	12.0	7.4	3.7	2.6	2.2	0.5	0.11
Harrison	1925–29	1,825	47.3	21.3	12.7	7.6	4.3	3.8	2.6	0.4	0
Two mile	1929	365	38.4	21.1	12.6	9.1	5.8	6.6	4.7	1.9	0
Four mile	1925–29	1,825	55.9	21.2	10.7	5.7	2.5	1.9	1.6	0.05	0
Dunne	1925–29	1,825	45.7	18.3	10.6	7.1	5.7	5.5	5.2	1.3	0.11
All cribs	1925–29	7,666	48.2	21.8	11.5	7.1	4.2	3.6	3.0	0.6	0.05

tests for residual chlorine. During periods when the chlorine absorbing qualities of the water are on the increase, these tests are made as often as every fifteen minutes. In addition, there are daily checks on operation by means of bacteriological analyses of samples of raw and chlorinated water, collected at each of the pumping stations, and from the distribution system; also independent daily checks are made of the chlorine battery scale weights and residual chlorine tests. The equipment is kept in first class condition at all times by frequent cleaning and servicing.

Special attention is paid to the meteorologic conditions, such as winds, rainfall and lake levels, all of which have great influence on the discharge of pollution into the lake, and the carrying of this pollution to the intakes. A study of these conditions makes it possible to forecast the pollution to be expected at the various intakes and to deter-

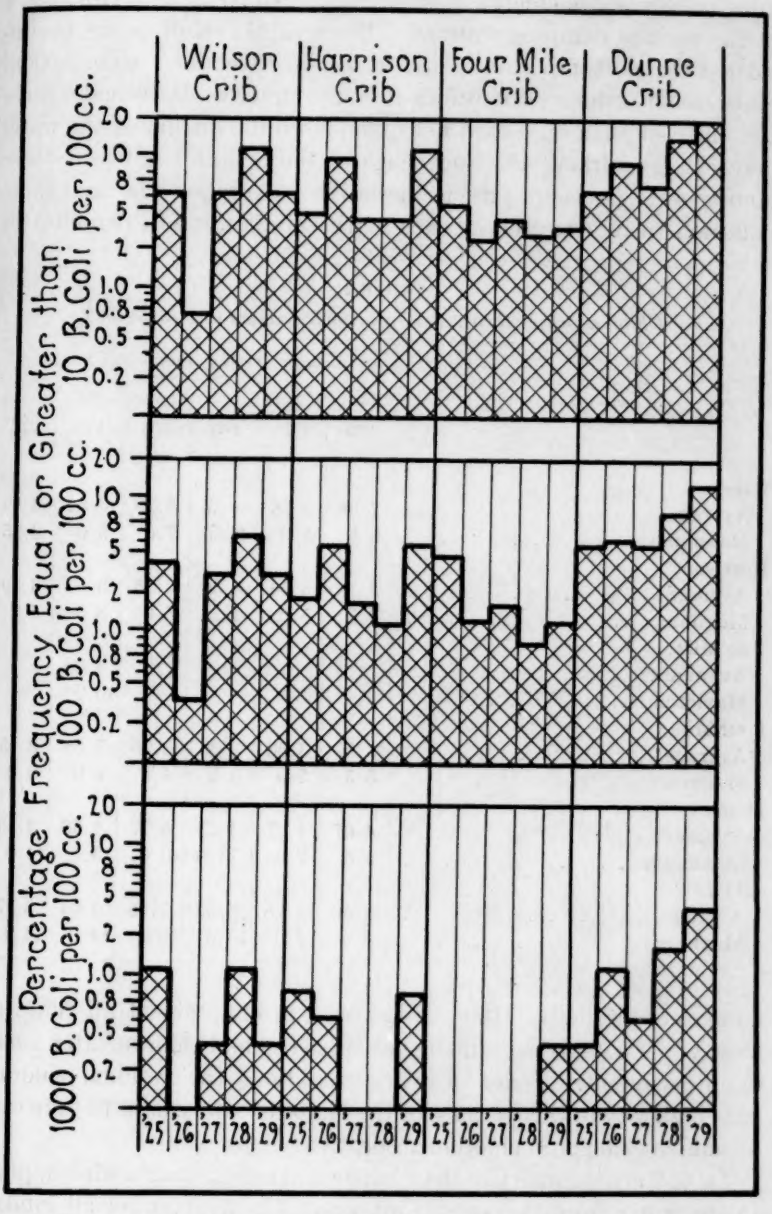

FIG. 1. FREQUENCY OF OCCURRENCE OF B. COLI PER 100 CC. (PHELPS). 1925–1929

mine the minimum chlorine dosages which can be carried with safety at the various pumping stations. The residual chlorine test is considered the most important gauge of the effectiveness of chlorination. Since under ordinary conditions it is not practicable to make these tests oftener than once each hour, and since the quality of the water may change without the knowledge of the operator between these hourly tests, it is at present desirable to forecast the maximum pollution to be expected at each of the intakes and to regulate the

TABLE 2

Chlorine applied to water from each crib intake, 1925–1929

CRIB INTAKE	CHLORINE APPLIED (POUNDS PER MILLION GALLONS)					
	1925	1926	1927	1928	1929	1925–1929
Wilson:						
Average	2.98	3.56	3.37	3.29	3.64	3.39
Maximum	5.5	5.0	9.25	7.0	9.0	9.25
Harrison:						
Average	3.19	3.54	3.30	3.25	3.67	3.39
Maximum	4.5	5.0	4.25	6.0	8.0	8.0
Two Mile:						
Average					4.08	
Maximum					10.0	
Four Mile:						
Average	3.56	3.50	3.36	3.25	3.58	3.45
Maximum	5.5	5.0	4.5	4.5	6.0	6.0
Dunne:						
Average	4.07	4.27	4.33	4.27	4.56	4.33
Maximum	5.5	7.0	14.0	10.0	13.0	14.0
All Cribs:						
Average	3.50	3.78	3.69	3.68	4.04	3.77
Maximum	5.5	7.0	14.0	10.0	13.0	14.0

dosages accordingly. It is endeavored to maintain at all times at least 1 to 2 pounds per million gallons of residual chlorine after a ten-minute contact. Under ordinary conditions the residual chlorine runs higher than this because of the factor of safety used to take care of sudden changes in chlorine absorption.

Table 2 is a summary of the average and maximum chlorine applied to the water from the various intakes. The average for all intakes for the period was 3.77 pounds per million gallon; the Wilson and

Harrison crib averages of 3.39 pounds per million gallon were the lowest; and that of the Dunne crib, 4.33 pounds per millon gallon, was the highest. The maximum dosage for the period of 14 pounds per million gallon was applied during 1927 to the Dunne crib water.

The high dosages were necessitated by the presence at times of chlorine absorbing substances in the water. At such periods the ordinary dosages of chlorine applied are entirely absorbed, leaving no residual chlorine to do the work of disinfection. It is then necessary to apply sufficient chlorine to satisfy the chlorine demand, plus an additional amount for residual chlorine. The chlorine absorbing substances may be divided into two types, the first being industrial and sewage wastes which are discharged into the lake from the Calumet region. Recent tests have shown that the dilution of as little as one part of ammonia still liquor in 10,000 parts of lake water will increase the chlorine absorbing properties of the water materially. The second type of chlorine absorbing substances are the finely divided particles, organic and inorganic, which are thrown into suspension by prolonged, severe lake storms.

EFFICIENCY OF CHLORINATION

The results of bacteriological analyses of the samples of raw and chlorinated water were studied for the purpose of determining the efficiency of chlorination as practiced in Chicago. These studies were made along the lines followed by Streeter[3] in his studies of the efficiency of water purification processes of plants on the Ohio River and Great Lakes.

The bacterial analyses were made in accordance with Standard Methods at the Chicago Health Department laboratories. The B. coli index for routine records is calculated by McCrady's method of probable numbers, but in order to make the results presented in this paper comparable with similar studies, the B. coli index has been calculated by the Phelp's method. The data may be taken to cover the results of five years of operation of a large number of individual chlorination plants; each of the various intakes may be considered to receive water of different bacterial quality on the same day, and the water from each of the intakes is distributed to two or more pumping stations, at which it is chlorinated separately. For the purposes of

[3] Public Health Bulletins Nos. 172 and 193, "Studies of Efficiency of Water Purification Processes," H. W. Streeter.

this study, the results of bacterial analyses of the chlorinated water from all pumping stations supplied by a single intake are grouped together. A single sample from the first sampling point of each crib tunnel system was taken to represent the daily quality of the raw water at the intake. The results of analyses of samples collected from the Two Mile Crib system were omitted for the years 1925 to 1928 because the water was prechlorinated at the crib during this period and, therefore, no record of the bacterial quality of the raw water was available.

The data are divided into various groups, according to the degree of pollution of the raw water and the corresponding quality of the

TABLE 3

Relation between B. coli index of raw and chlorinated water at Chicago, Ill., 1925–1929

RAW WATER		CHLORINATED WATER	
Average B. coli per 100 cc.	Number of crib days	Average B. coli per 100 cc.	Number of samples
0 2 } average 0.63	5,355	0.042	30,498
4 6 8 10 } average 5.98	2,025	0.067	12,367
100	233	0.074	1,590
1,000	48	0.187	353

chlorinated water, and the averages of these groups are calculated, as shown in table 3. The data in table 3 were plotted on a double logarithmic scale in figure 2. It shows the relation between the B. coli index of raw and chlorinated water. It may be readily seen that there is a distinct relationship between the quality of the raw and chlorinated water, the points plotted adhering very closely to the straight line for which an equation may be obtained. This relation is similar to that first demonstrated and enunciated by Wolman[4] and later confirmed by Streeter[3] in their studies of efficiencies of purification processes. The slope of the line plotted would indicate that with

[4] Journal, September, 1918, page 272.

the method of chlorination practiced in Chicago, a raw water having an index of 5 million B. coli per 100 cc. may be treated to produce an effluent which will pass the U. S. Treasury Standard. No such efficiency can be attained in practice because of the fact that as the pollution becomes greater the chlorine absorbing substances in the water increase, making the maintenance of sufficient residual chlorine for disinfection increasingly difficult and requiring abnormally high dosages of chlorine. Even under present conditions it is difficult to maintain residual chlorine in the water during certain periods. It is only by strict supervision over chlorination, and high dosages at times, that the present efficiencies can be maintained.

The chlorinated water has at all times passed the requirements of the U. S. Treasury Department standard for a safe water. Table 4

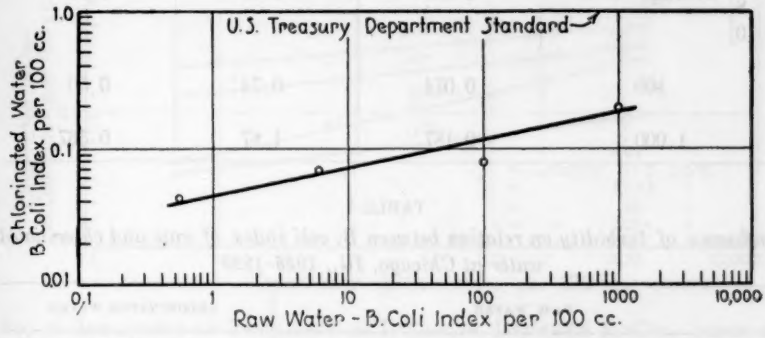

FIG. 2. RELATION BETWEEN B. COLI INDEX OF RAW AND CHLORINATED WATER AT CHICAGO. 1925–1929

is a summary showing how chlorinated water corresponding to various degrees of raw water pollution met these requirements.

INFLUENCE OF TURBIDITY ON EFFICIENCY

For the purpose of studying the effect of turbidity of the raw water on the efficiency of chlorination, the data are sub-divided into groups of similar turbidity, as shown in table 5. These data are plotted in chart form in figure 3. They show strikingly that the efficiency of chlorination decreases with increased turbidity. A small factor in this trend may be that with increases in turbidity there are also increases in chlorine absorptive properties, which make chlorination more difficult. This, however, accounts for only a small portion of

TABLE 4

Summary showing how the chlorinated water corresponding to various degrees of raw water pollution met the different requirements of the U. S. Treasury Department Standard for a safe drinking water, 1925–1929

RAW WATER	CHLORINATED WATER		
Average B. coli per 100 cc.	Average B. coli per 100 cc.	Percentage of 10 cc. portions positive	Percentage of samples which were 6 B. coli per 100 cc. or more
	Maximum allowed, 1.0	Maximum allowed, 10 per cent	Maximum allowed, 5 per cent
0, 2, average 0.625	0.042	0.42	0.15
4, 6, 8, 10, average 5.98	0.067	0.67	0.25
100	0.074	0.74	0.50
1,000	0.187	1.87	0.567

TABLE 5

Influence of turbidity on relation between B. coli index of raw and chlorinated water at Chicago, Ill., 1925–1929

RAW WATER			CHLORINATED WATER	
Average B. coli per 100 cc.	Turbidity, p.p.m.	Number of crib days	Average B. coli per 100 cc.	Number of samples
0, 2, average 0.65	0–9	3,291	0.0368	18,473
0.565	10–49	1,993	0.0433	11,966
1.21	50 over	71	0.158	450
4, 6, 8, 10, average 5.92	0–9	1,168	0.0442	7,110
6.06	10–49	779	0.082	4,447
6.77	50 over	121	0.146	723
100	0–9	133	0.070	973
	10–49	69	0.063	431
	50 over	31	0.124	192
1,000	0–9	21	0.0835	168
	10–49	12	0.27	89
	50 over	15	0.292	96

the trend, because an increase in chlorine absorption due to this cause is not observed until the turbidity becomes quite high.

FUTURE OF CHLORINATION AT CHICAGO

During the last few years there has been an increase in the pollution of the lake water off Chicago, mostly by wastes discharged from the Calumet region. The indications are that pollution will continue to increase, especially in light of the recent Supreme Court decision which ruled that diversion from Lake Michigan into the Drainage Canal should be progressively reduced in the next nine years. It is estimated that during 1929, 6,500 million gallons of water having abnormal chlorine absorptive properties were pumped into the dis-

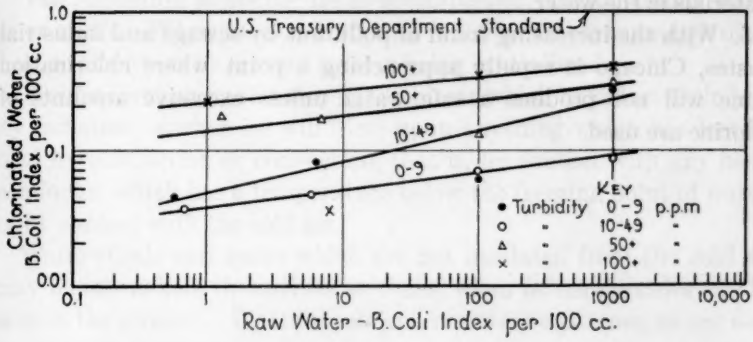

FIG. 3. INFLUENCE OF TURBIDITY ON RELATION BETWEEN B. COLI INDEX OF RAW AND CHLORINATED WATER AT CHICAGO. 1925–1929

tribution system or approximately 1.7 percent of the total yearly pumpage.

Production of a safe drinking water by chlorination alone will become increasingly difficult. The high chlorine dosages required at times for effective disinfection will cause objectionable tastes and odors. This, coupled with the turbidity after each storm on the lake and the obnoxious algae tastes and odors, will make the water more and more unpalatable, until a time will come when the public will refuse to use it for drinking and domestic purposes. Such a condition would probably produce grave physiological effects on the health of the citizens of Chicago.

Tests have shown that filtration will easily produce a satisfactory water. Chicago must make a determined effort to install such plants as soon as possible.

SUMMARY OF CONCLUSIONS

1. There appears to be a definite relationship between the bacterial quality of the raw and chlorinated water.

2. The efficiency of chlorination is influenced by the presence of turbidity in the water, the greater the turbidity the less the efficiency.

3. Using chlorination as the only treatment, Chicago has been able to produce a water well within the U. S. Treasury Department standards in spite of the widely varying characteristics of the raw water.

4. The efficiency of chlorination in Chicago is entirely dependent on the strict supervision maintained, which relies for its success on the continuity of operation, and early detection of chlorine absorbing materials in the water.

5. With the increasing trend of pollution by sewage and industrial wastes, Chicago is rapidly approaching a point where chlorination alone will not produce a safe water unless excessive amounts of chlorine are used.

ANCHOR ICE TROUBLES[1]

By Charles H. Lord[2]

In northern climates anchor ice and frazil are a source of annoyance, trouble, and expense to water departments and hydro-electric plants.

Anchor ice will form upon metal, rock, or any dark thing which has lost its heat by radiation, when water "at the freezing point" is agitated by coming in contact with the cold thing in question.

The formation of anchor ice is accomplished only on cloudy days, or at night. When the sun is shining it always imparts enough of its heat to the water to prevent it from being crystallized.

Besides forming upon submerged objects which have lost their heat by radiation, anchor ice will form upon anything which has lost its heat by conduction or convection, that is, by contact with any heat-conductor which has a temperature below the freezing point of water, or by contact with the cold air.

Waterwheels and racks which are not insulated from the cold air may be ice-makers themselves at times, when no ice particles can be seen in the stream. Waterwheels and racks are agitators, as are also water works' intakes.

Frazil, which is the floating feathery stuff that forms upon the the surface of all open waters, will cling like a cat's claw to every cold thing it touches. And it "runs like fire" as each particle acts as a nucleus for the formation of others. Frazil will cling to its "brothers," to anchor ice, to anything and everything which is at a temperature exactly at or below the freezing point of water.

From the foregoing facts it may be seen that waterwheel, rack and intake troubles may be due to a combination of anchor ice forming upon them, and frazil which is carried in to them.

In my opinion both forms of ice are alike. They are formed by agitating supercooled water. Anchor ice clings to whatever object it forms upon. It remains anchored to the beds of streams until loosened by heat from the sun.

[1] Presented before the New York Section meeting, October 10, 1930.

[2] Engineer, Board of Public Control, Ogdensburg, N. Y.

On bright mornings in open streams below rapids in winter often there will be noticed particles of ice floating with particles of earth, weeds, etc., clinging to them. The anchor ice forms at the bottom of the stream during the night clinging to whatever may be there. This condition holds until the sun loosens the ice in the mornings.

EXPERIENCES AT OGDENSBURG

Our experiences at Ogdensburg have shown us that in the Oswegatchie River, from which stream we derive water for power purposes, when the water reaches a temperature very nearly that of freezing, with a very cold wind from the north or northwest, when the river is open, we are very likely to be troubled with anchor ice after sunset. After the river has frozen over we are no longer troubled with it. Anchor ice is generally more troublesome before the surface ice forms in the fall or early winter than it is in spring after the breaking of the surface ice, probably because of the fact that the sun sets later in the evening, and rises earlier than in the winter.

On many occasions at our Oswegatchie pumping station anchor ice has formed on the inlets of the water turbines, and frazil has fastened upon the moving parts of the turbines, and shut them down even before these two varieties of ice had formed on the racks in sufficient quantities to shut off the water flowing to the turbines.

In other cases sufficient amounts of anchor ice and frazil have formed on the racks to shut off the water entirely in the forebay, so that the space between the racks and the tailrace would be entirely free from water.

The intake of the St. Lawrence pumping station begins about 600 feet from the river shore, and in about 35 feet of water, and only on two occasions since 1912 has anchor ice entirely shut off the water coming into the pumping station well. The first occasion was in February, 1913, and it took the operator of the filtration plant and St. Lawrence pumping station by surprise, as it was believed that the depth of 35 feet at the mouth of the intake would preclude any possibility of anchor ice. The first indication of the condition was noticed when the ammeter on the power line at the Oswegatchie Station showed that the load on the motor driven pump at the St. Lawrence Station was away below normal. Power for the pump at the St. Lawrence Station was being developed at the Oswegatchie Station, and transmitted to the St. Lawrence Station. The operator for the filtration plant and St. Lawrence Station was at the filters, and so did

not notice the condition. When he was notified, and sent to the St. Lawrence Station it was found that anchor ice had entirely shut off the water coming in through the intake, and the pump had pumped all of the water out of the well, thus causing it to lose its load. Although this was in February, up until that time the weather had been mild, and the St. Lawrence had not frozen, except a few feet out from its shores. What seemed the only remedy for the situation was to fill up the well to the level of the pump-room floor with water, and let the water run out into the intake, it being considered that the ten foot head from the pump-room floor level to the surface of the river would free the ice blockade.

The fire department was requested to furnish a fire engine, and it was taken to the pumping station, and the well was pumped full from the river, the 30-inch gate valve on the well end of the intake having been closed, and after the well was filled, the gate valve was opened, but this operation was so slow that the water in the well ran back into the intake without any good results.

After trying the above remedy several times it was decided to build a wooden pad larger than the opening of the 30-inch valve, leave the valve open, and after filling the well by means of the fire engine suddenly lift the pad so that the water might rush quickly out into the intake. Two upright arms of two by four material were made long enough so that men standing on the pump-room floor could by means of cross pieces on the two by fours lift the pad quickly.

This was done, and with very gratifying success, the ice blockade was driven out. The anchor ice shut the water off from the intake about midnight, and it was freed of anchor ice about six o'clock in the morning.

Fearing that there might be a repetition of this occurrence later, and not wishing to wait for a fire engine for aid, it was decided to tap one of the suction mains, and put on a 6-inch gate valve by which means water could be let into the well from the main leading from the St. Lawrence Station to the filters, the filters being about 55 feet higher than the pumping station. On the night of the trouble mentioned above, it was dark and cloudy, and there was a strong cold wind from the northwest carrying a great deal of snow with it.

While at various times after that anchor ice gave a little trouble, and made its appearance in the pump well, it was not until the night of December 29, 1924, that serious trouble was again experienced. At this time the St. Lawrence River had not frozen over, although the

water was extremely cold. For several days a strong cold wind had blown from the northwest, and at about six o'clock in the evening of the 29th, the filter foreman reported that some ice was coming into the well. At nine o'clock the supply coming in through the intake was entirely cut off, and preparations were made to get rid of the ice. A crew of about 12 men were gotten together, and the work of endeavoring to free the intake commenced.

For hour after hour the well was filled with water from the main leading to the filters, and the pad lifted, but without any appreciable results. About daylight on the morning of the 30th, arrangements were made with the shipyard at Ogdensburg, whose plant adjoins the St. Lawrence Pumping Station, to send out a steamboat with a bell diver with full equipment to the end of the intake, with a view to having the diver go down and free the ice from the end of the intake. The river was very rough, the wind of several days past having caused a heavy sea. Out over the end of the intake there was considerable floating ice.

After considerable maneuvering, in endeavoring to get over the end of the intake, the boat let down her forward and after anchors, and the diver went over the side and down into the river. After a considerable time the diver signalled to be brought up, and when he had come on board and his helmet was removed, he reported that it was dark along the bottom of the river on account of the lack of sunshine, the turbid water and floating ice, and that he was unable to locate the mouth of the intake. Meanwhile, considerable difficulty had been experienced in holding the boat over the spot desired, and it was decided to give up the idea of having the diver try to free the ice from the mouth of the intake.

The writer had about determined to use dynamite to blow up the intake nearer shore, in order to get water into the well, when the sun came out, and the wind shifted to northeast, and then anchor ice with weeds, moss, bark, etc. came rushing into the well with the water, and the trouble was over for the time at least. This relief came about two o'clock in the afternoon of the 30th, and the filters and reservoir were about depleted of water, although the pumps at the Oswegatchie Station, which is in reality a booster station, had been pumping with greatly reduced pressure to the consumers.

On the morning of the 31st. ice was found to have frozen out over the end of the intake, and trouble from anchor ice was past at least until a breakup of the ice in the St. Lawrence.

Inasmuch as our system is one of direct pumping, had a serious fire broken out during our trouble we should have found ourselves in a bad situation.

Running a steam line out through the intake to aid in freeing the intake in cases like the above has been considered, but on account of the considerable length through the cold water, and because of the several vertical bends in the intake, this idea has not been carried out.

It is believed, however, that, if an air compressor of sufficient capacity were installed at the St. Lawrence Station, and taps installed in the intake outside the 30-inch valve, some relief might be obtained by creating an outward air pressure during the formation of anchor ice at the mouth of the intake.

If the anchor ice condition recurred every year, it would be advisable to build a pier of concrete and steel at the end of the intake, place a boiler house on the pier, and by means of a steam boiler with pipes leading down to the intake heat the water passing into the mouth of the intake, which it is believed would remedy matters. This would be very expensive, however, and on account of the depth of water at the intake anchor ice in sufficient quantities to cause great trouble has formed only twice in eighteen years.

Some water departments and power plants have found it advantageous to install revolving screens at their intake inlets and racks, by means of which the anchor ice, and frazil are drawn up into a compartment where they are removed by heat, steam, or other means.

Previous to 1912 the city of Ogdensburg took its water supply from the Oswegatchie River, and great trouble was experienced with anchor ice in the intake on account of the comparative shallowness of the stream. At times it was necessary to use dynamite to free the intake, and on several occasions portions of the intake were blown up, and had to be repaired later.

Almost every winter, until the Oswegatchie freezes over, trouble is experienced with anchor ice, and frazil clogging racks and turbines, and the same condition holds in the spring after the surface ice has gone out until the water has become warm enough to do away with the condition.

On some occasions it has been found of benefit to have men with long rack rakes work at the racks keeping them free from anchor ice and frazil, but even though this has been of benefit in some cases, the anchor ice and frazil have formed in the passages of the turbines, thus shutting them down.

While methods have been devised to combat anchor ice and frazil, in this section of the country they still continue to be a source of trouble to power plant and water works operators.

In the matter of power the city water department at Ogdensburg has steam and electric auxiliary power, so that anchor ice only causes the trouble of shifting to other sources of power, but anchor ice and frazil in the intake are more serious troubles.

THE RECENT DROUGHT AND NEW YORK STATE WATER SUPPLIES[1]

By Earl Devendorf[2]

At times of drought public water supplies are subjected to danger through shortages, with the result that often polluted sources are used, or through the inadequate dilution afforded pollution by low stream flows. Moreover, with heavy rainfalls following droughts, accumulated pollution may be washed suddenly and directly to the water supply intakes creating a great menace to water supplies, since the existing purification processes may be inadequate to treat effectively such great and unusual increases in pollution. If the operation of the treatment plant is temporarily ineffective at such times great danger exists of an outbreak of waterborne disease. While underground supplies ordinarily are not so directly subject to danger during or following periods of drought their proper protection is especially important at such times as the degree of danger varies greatly and is dependent upon the depths of the wells or springs, the nearness and character of the sources of pollution, the character of the soil, type of well casing or spring enclosure, etc.

Perhaps the most serious menace at times of drought with resulting water shortage exists through the use of emergency sources of supply which are often of unknown safety. It is of the utmost importance from the public health standpoint that the use of unsafe sources of supplies be avoided or that proper and effective purification be afforded to treat such supplies before their delivery to the public. Some times connections are made to industrial supplies known to be unsafe. Their use should only be permitted in extreme emergencies and then only after effective treatment under the direct supervision of the water supply and health officials.

The recent drought has been so widespread and of such long duration that it has commanded the attention of public officials, engineers

[1] Presented before the New York Section meeting, October 9, 1930.

[2] Associate Director, Division of Sanitation, State Department of Health, Albany, N. Y.

and the general public of the whole country. Although, as usual, agriculture has been the first to feel the effects of the present drought, its long and continued duration has resulted in depleting many of the public water supplies of New York State. While the attention of governmental agencies has been directed toward providing relief to the farmer, in a like manner, the attention of public health officials and engineers has been directed toward the many instances of water supply shortages which have necessitated the use of auxiliary and often questionable or polluted sources of supply.

Considering the 600 public water supplies in New York State, time will not permit me to go into any great detail concerning the individual water supplies. While such a study would be of great interest and importance, it would not only require observations and records covering a long period of time, but it is too early to know of the full effects of the present drought on many of our water supplies in the state, especially on those derived from ground water sources.

RAINFALL DATA

The rainfall records of the country have shown that the drought has extended over wide areas and it has been classed as probably the greatest drought experienced in American history. In some portions of the country the drought began as early as last fall. With the exception of the extreme southwest and part of New England, the drought has extended over practically the whole of the United States east of the Rocky Mountains. The greatest deficiencies in rainfall have extended up the Mississippi and Ohio river systems from the Gulf of Mexico and on across to the Atlantic seaboard.

The normal average rainfall for New York State varies considerably in the various sections of the state. The figures in table 1 give the normal rainfall in the various sections as obtained from the United States Weather Bureau.

An examination of the rainfall records of the United States Weather Bureau Stations in New York State indicates that from January 1 to October 1, there is an accumulated deficiency of 3.33 inches of rainfall and that the rainfall has varied greatly in various sections of the state. In some parts of the state there has been a considerable deficiency in rainfall this year while in others the rainfall has been normal or in excess thereof.

The records in table 2 indicate that, in general, the southern,

eastern and western portions of the state were generally deficient in rainfall, whereas in a portion of the central and northern parts of the state, the rainfall was either normal or above normal. This rainfall, however, was distributed unevenly, the rainfalls being quite generally in excess in the early part of the year, whereas in the middle and latter part of the summer, the rainfall has been quite generally deficient.

In an endeavor to obtain some concrete evidence of the effect of the drought on stream flows in the state, the information given in table 2 relative to the flow of streams in respective parts of the state was obtained from A. W. Harrington, Engineer in charge of the United States Geological Survey Office in Albany. These stations, where records in excess of ten years are available, have been selected

TABLE 1

Normal annual rainfall in New York State

LOCATION	ANNUAL RAINFALL
	inches
In the section around New York City and Long Island	40–45
Hudson Valley, lower portion	40–45
Hudson Valley, upper portion	35–40
The Mohawk Valley in the eastern part of the state	35–40
The Adirondack section	40–50
Champlain Valley	30 and less
St. Lawrence Valley	30–35
The section bordering on Lake Erie and Lake Ontario	25–35
The Central or Finger Lakes Region	30–35

from representative sections. The records are interesting and indicate that in certain sections of the state the stream flows this summer have established a new record for minimum stream flows. In other sections of the state the stream flows have been in excess of the previous record for low flows. In general, record low stream flows have occurred in streams in the southern and western areas of the state, whereas in the eastern and northern areas the stream flows are generally equal to or considerably in excess of the previously recorded low flows. I call your attention particularly to the record of minimum flow of the St. Regis river where the minimum this year has been five times that of the low flow previously recorded while the record minimum flow for the Conesus outlet was nearly half that of the previous low flow record. It is to be noted that, in general,

TABLE 2

Precipitation in inches

MONTH (1930)	NEW YORK STATE	DEPARTURE FROM NORMAL		BINGHAMTON	DEPARTURE FROM NORMAL		ALBANY	DEPARTURE FROM NORMAL		CANTON	DEPARTURE FROM NORMAL		BUFFALO	DEPARTURE FROM NORMAL		ROCHESTER	DEPARTURE FROM NORMAL		ITHACA	DEPARTURE FROM NORMAL	
		+	−		+	−		+	−		+	−		+	−		+	−		+	−
January	3.12	0.21		1.77		0.68	1.77		0.63	3.98	1.48		6.23	2.93		2.92	0.03		1.66		0.53
February	1.72		1.01	1.62		0.65	1.04		1.42	0.50		1.77	2.11		0.84	1.90		0.79	1.45		0.53
March	3.53	0.52		2.46		0.16	2.76	0.14		4.38	1.88		3.34	0.77		4.59	1.83		3.92	1.61	
April	2.07		0.90	2.30		0.18	1.53		0.93	2.18	0.0		1.29		1.27	1.51		1.25	2.46		0.05
May	3.63	0.11		4.18	0.87		3.02	0.12		3.10	0.10		1.17		1.93	2.53		0.41	3.49		0.09
June	4.33	0.63		5.89	2.50		3.21		0.16	4.39	1.10		3.31	0.49		4.07	1.07		6.85	3.29	
July	2.97		0.96	2.35		1.35	4.33	0.90		3.54	0.04		2.02		1.01	2.15		0.81	3.75	0.21	
August	2.41		1.41	1.54		2.05	2.20		1.51	1.24		2.41	0.69		2.39	2.05		0.83	1.49		1.89
September	2.89		0.52	5.37	2.28		1.96		1.15	1.51		1.84	2.92		1.36	1.55		0.90	2.07		0.99
Total		1.47	4.80		5.65	5.07		1.16	5.80		4.60	6.02		4.19	8.80		2.93	4.99		5.11	4.08
Accumulated excess or deficiency since January 1, 1930			3.33		0.58+				4.64−			1.42−			4.52−			1.65−		1.21+	

these records correspond to the rainfall records of the respective sections of the state.

EFFECT OF DROUGHT

The drought first affected our streams and surface water supplies. With the continuation of the drought many of our ground water sources have naturally been seriously affected. Little definite information or data are available on the depletion of the ground water sources by the continued drought, except through the failure of wells and springs to deliver their usual quantity of water. It is quite common, however, that following such failure or depletion of ground water sources a great length of time is usually required for these sources to be replenished. In a recent article in the *Engineering News-Record* it appears that some engineers believe that many of the ground water sources of North Carolina had not entirely recovered from the drought of 1925.

Beginning as early as the latter part of July we began to receive reports of water supply shortages. It was not until August and September, however, that the larger number of shortages in public water supplies occurred. The Department is still being advised by water officials in various sections of the state of the depletion of the regular sources of supply and the necessity of using some auxiliary source. Unless we experience copious rains during the next month there is little doubt that many of our water supplies will be seriously affected, for, with the exception of the larger rivers and lakes, nearly all storage reservoirs on surface water supplies have been seriously depleted and the ground water supplies will be benefited but little by rainfall after the ground freezes.

Among the first of those municipalities whose water supplies were affected this year were the ones whose sources or whose storage reservoirs were known to be inadequate and where similar water shortages have occurred previously. The long duration of the drought this year has resulted, however, in shortages or the depletion of water supplies where previously such shortages have been unknown or of very infrequent occurrence.

Among the larger and more important cities of this state whose public water supplies have been affected by the drought is Gloversville where such a serious shortage as was experienced this year was previously unknown. The shortage became so serious as to result in the closing of manufacturing plants for a period of some

TABLE 3

United States Geological Survey, New York District, Albany, N. Y.

STREAM	LOCATION OF GAGING STATION	PERIOD OF RECORD	DRAINAGE AREA	MINIMUM MEAN DAILY DISCHARGE			
				Prior to September 30, 1929		Prior to September 30, 1930	
				Amount	Date	Amount	Date
			square miles	*second-feet*		*second-feet*	
Allegany River	At Red House, Cattaraugus County, N. Y.	Sept., 1903, to Sept., 1930	1,640	114	Aug. 5, 27, 28, 1923	95	Sept. 11–14, 24
Genesee River	At Scio, Allegany County, N. Y.	June, 1916, to Sept., 1930	288	16	Sept. 3, 1925, to Sept. 29, 1927	16	Aug. 13, 14, 19, 22, Sept. 12, 13
Conesus Creek	Near Lakeville, Livingston County, N. Y.	Nov., 1919, to Sept., 1930	72	0.7	Nov. 22, 1923	0.4	Sept. 13
Tioga River	Near Erwins, Steuben County, N. Y.	July, 1918, to Sept., 1930	1,320	29	Sept. 3, 1929	35	Sept. 12
East Branch Delaware River	At Fishs Eddy, Delaware County, N. Y.	Nov., 1912, to Sept., 1930	785	97	Oct. 14, 15, 1914	106	Aug. 11
Sacandaga River	Near Hope, Hamilton County, N. Y.	Sept., 1911, to Sept., 1930	494	18	Sept. 20, 1913	65	Sept. 12
Hudson River	At Gooley near Indian Lake, Hamilton County, N. Y.	Aug., 1916, to Sept., 1930	420	44	Aug. 23, 24, 1923	85*	Sept. 12, 13
St. Regis River	At Brasher Center, St. Lawrence County, N. Y.	Aug., 1910, to Nov., 1917; Jan., 1919, to Sept., 1930	616	37	Aug. 8, 1917	201	Sept. 8 and 16

* Estimated from record of Hudson River near Newcomb, N. Y.

three weeks until auxiliary pumping machinery could be provided and piping laid to obtain water from nearby ponds which are still being used to augment the regular sources of supply. All the water supplied the city was effectively chlorinated under the careful daily supervision of the city authorities and analyses have indicated the water delivered to be of a safe sanitary quality. It was estimated that the shutting down of the plants affected some five to seven thousand employees, while the cost to the manufacturers, although unknown, has been considerable.

Medina may be cited as an example of a municipality having to resort to the use of a seriously polluted source of supply to augment its regular source of supply obtained from ground water sources which were depleted by the drought. Here the Barge Canal water was used. The canal water is partly obtained from Tonawanda Creek and the Niagara River, both being polluted streams. Although the water first pumped from the canal was inadequately chlorinated because of the insufficient capacity of the chlorinator on hand, this was corrected with the immediate purchase and installation of a larger capacity machine and no outbreak of waterborne disease resulted, although it was at first feared that this might occur.

A number of other municipalities have thus far reported shortages. In some instances auxiliary sources of supplies were resorted to; in others additional or new wells were drilled or new spring supplies developed. In all cases where water supply shortages have been experienced there are movements under way either to obtain new or additional sources of supply or to increase existing storage reservoirs.

For the city of Hudson a pitometer survey of the water supply distribution system made something over a year ago has undoubtedly resulted in preventing a serious water shortage this year. On a number of occasions in the past the regular source of supply was nearly depleted and in at least one instance in recent years it became necessary to resort to the use of an auxiliary source. Realizing that the amount of water used was excessive the city undertook a water waste survey which revealed two large sources of water waste, with the usual discovery of smaller water wastes. By correcting these conditions and by house to house surveys of fixtures to discover and eliminate losses through leaking fixtures, the amount of water used has been greatly reduced.

As a result, this year, in spite of the long continued drought, there is no sign or danger of a water shortage.

* Estimated from record of Hudson River near Newcomb, N. Y.

Sept., 1930

In conclusion, it is apparent that, while many of the public water supplies in the state have been affected to varying degrees by the drought this summer, the number of supplies seriously depleted has been relatively few. Many of the reservoirs particularly of the surface water sources are at low levels. With the time for usual fall rains approaching, it is believed there will be no great additional number of supplies affected unless the usual fall rains should fail to occur before the ground freezes.

This paper should not be closed without commenting on the absence of any waterborne outbreak thus far this year following the use of auxiliary sources of supplies, some of which were known to be seriously polluted. This is undoubtedly largely due to the coöperation of the water supply authorities and health officers in reporting to the State Commissioner of Health before using auxiliary supplies, as required by the State Sanitary Code. It has thus been possible for the Department Engineers to supervise the installation of emergency chlorination plants where such treatment was believed necessary and to assist in the protection and development of emergency sources of supply.

REMOVAL OF IRON FROM WATER SUPPLY, PUNTA GORDA, FLORIDA[1]

By Charles K. Dodd[2]

The water supply for the city of Punta Gorda is obtained from five 6-inch wells which are screened between depths of 60 and 90 feet, the water coming from a fine sand stratum between these two points. These wells were put down in 1925 to replace the old deep flowing wells which were heavy in sulphur and hardness, in an attempt to get softer water and water free from sulphur. The new wells yielded a very good quality of water for several months, but continued pumping brought about a continual increase of iron and magnesium content so that in 1929 the water contained 19.6 p.p.m. of iron and magnesium. The water became very objectionable, both as to taste and stains resulting from its high iron content.

No attempt will be made in this paper to elaborate on the various objections to water with high iron content, since most of you are familiar with its damaging effects either from experience with your own water plants, or through observation of its effect in other plants.

Punta Gorda was confronted with the necessity of doing something and of doing it at a time when its finances were very limited. It was not thought necessary at this time to attempt to soften the water, but simply to remove the iron and sulphur and, if possible, do this without the use of chemicals. Experiments to this end were carried on over a period of about eighteen months. It was then decided to use aeration in connection with an upward flow contact filter. This plant was built at a very small cost and has proven very satisfactory. With it we were able to reduce the iron content from 19.6 to 0.1 p.p.m.

TREATMENT FOR IRON REMOVAL

Iron in solution when mixed with oxygen will form a reddish brown precipitate of iron oxide. This precipitate has a tendency to cling

[1] Presented before the Florida Section meeting, April 10, 1930.

[2] Department of Water Supply, Punta Gorda, Fla.

to any smooth surface and if the surface is already coated with a thin coating of iron oxide, it will cling to it much more readily. This principle is taken advantage of in our iron removal plant.

The well water is pumped through a 4-inch pipe to the top of a square wooden tank 5 feet wide, 10 feet long, and 4.5 feet high. This wooden tank is filled two-thirds full of broken pieces of terra cotta pipe over which the raw water is distributed through twelve 0.5-inch holes tapped into the 4-inch pipe. The splashing of the water over the pieces of broken terra cotta pipe is all the aeration it receives. Leading from the bottom of this open top tank, which we call the aeration tank, we have placed a 4-inch angle valve by means of which the water level in the aeration tank may be regulated. The aeration is regulated by controlling the discharge with the angle valve, thereby controlling the depth of submergence of the broken pieces of terra cotta pipe. It is necessary to provide for this regulation so as to prevent excessive aeration, as excessive aeration, depending on the amount of organic matter in the water, may prevent proper functioning of the gravel filter, through which the aerated water later passes.

Immediately beneath the aeration tank is another square wooden tank 5.67 feet wide, 11 feet long and 9 feet deep which contains the gravel filter. The aerated water flows by gravity into an upright 8-inch open end stand pipe, the top of which is 5 feet above the top of this lower tank, from which it is conducted to the bottom of the wooden tank just mentioned and distributed over the bottom by means of a crow foot arrangement, consisting of one piece of 8-inch pipe 10 feet long, and twenty pieces of 2-inch pipe leading from this and spaced every 6 inches. There are ten $\frac{3}{4}$-inch holes spaced every 6 inches in each 2-inch pipe, and these holes face downward toward the bottom of the tank. This gives an even distribution of water all over the bottom of the tank so that the water flows upward through the upward flow gravel filter. This filter was built out of smooth pebble gravel as follows: the first or bottom layer is composed of gravel from 1 to 2 inches in diameter, and is 18 inches thick. The next stratum above is composed of gravel in size from $\frac{1}{2}$ to 1 inch in diameter, and is 12 inches thick. The next stratum is gravel $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter and is 12 inches thick. The next is gravel $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter and is 18 inches thick. The last and top stratum is of gravel $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter and is 24 inches thick. This makes the total depth of gravel bed 7 feet, which after the agitation caused by washing forms an evenly graduated gravel filter bed with coarse

2-inch gravel at the bottom decreasing to one-twelfth diameter at the top.

The aerated water falls by gravity into the 8-inch stand pipe which conducts it into the bottom of the gravel bed distributed by means of the crow foot arrangement, and flows upward through the gravel bed at the rate of 2.5 gallons per minute per square foot of horizontal filter area. The aeration of the water has been controlled so that the oxidation of the iron is completed while the water is passing through the gravel bed. This is necessary because it is found that, if the water receives too much aeration, the precipitate of iron oxide will form before the water gets to the gravel bed and a portion will pass through without clinging to the gravel. After the water passes upward through the gravel bed it is perfectly clear and is carried off to a clear well through an overflow pipe approximately 12 inches above the top of the gravel bed. From this overflow pipe the water splashes into an open wooden tank giving it a further aeration, which removes part of the excess carbon dioxide, and from this last aeration tank the water flows by gravity into a 270,000 gallon concrete reservoir from which it is pumped into the mains.

As the gravel filter gets loaded with iron the head necessary to force the water upward through the gravel bed increases. This causes the water to stand higher in the open end 8-inch standpipe and when it rises high enough to overflow the standpipe it is necessary to downwash the filter. Downwashing is accomplished by opening an 8-inch valve which allows the water in the gravel bed to flow rapidly downward and out through the crow foot arrangement in the bottom of the bed, thence to a waste pipe. In downwashing the water level in the bed is only lowered down to the surface of the gravel bed. Care should be taken not to let the water surface get below the top of the gravel bed in order to keep air from getting into it. Downwashing this plant requires only about 450 gallons of water and when running the plant continuously it is necessary to downwash once every twenty-four hours. When it becomes necessary to downwash more frequently than once every twenty-four hours, (which is usually once a week), the gravel bed is upwashed.

Upwashing requires 15 gallons per minute per square foot of horizontal area of gravel bed. In our case 1,000 gallons per minute is forced upward through the crow foot arrangement at a pressure of 75 pounds per square inch. This agitates the whole filter bed and rubs each piece of rock against its neighbor which scrapes off all the surplus iron clinging to it. The iron all boils to the top of the filter

and passes out through an overflow pipe to a waste pipe. Approximately 3,000 gallons of water are required to upwash our filter.

After upwashing the filter it is necessary to leave the waste overflow open until the water coming from the gravel bed is again clear. This usually requires from five to ten minutes after which the clear water may be again diverted into the reservoir.

The capacity of the gravel bed described is 166 gallons per minute, or two and one-half gallons per minute per square foot of gravel bed. The gravel bed never needs changing and to the contrary the longer it remains in use the better it works. It will be noted that very little water is wasted compared to the gross amount of water passing through the plant. This plant has a capacity of approximately 230,000 gallons per day, of which less than one-half of 1 percent is lost in washing processes. It requires no especial attention with the exception of downwashing once a day and upwashing approximately once a week. No chemicals are added to the water at all.

Means are provided in the piping and connections to control every phase of operation and platforms are provided giving access to all parts of the plant for ease of inspection and operation. The plant is also constructed so that with very little expense it may be increased to twice its present capacity.

The size of a plant of this kind is limited only by the amount of water available for upwashing, since this requires 15 gallons per minute per square foot of horizontal area of gravel bed. However, any number of gravel bed units could be built of a size limited by the volume of wash water available and arranged so that they could be washed one at a time.

The City of Punta Gorda has two 1,000 gallon per minute emergency pumps for fire protection and one of these pumps is used in upwashing our filter.

Due to the improved quality of the water our water sales have doubled since installation of this plant. It is estimated that the plant paid for itself in four months time, due to the increased use of city water. This increase is largely due to the fact that our city water may now be used for lawn sprinkling purposes, whereas the old water contained enough iron to stain grass, foliage, and buildings wherever it was used for lawn sprinkling.

It is difficult for one to appreciate the enormous amount of iron in a days supply of water such as ours, without watching the effluent of the downwashing process which appears to the eye to be just so many gallons of red barn paint. Considerable interest has been evinced in our plant and visitors are always welcome.

THE PROBLEM OF THE OLD EMPLOYEE[1]

By N. Wallis Streat[2]

The problem of the old employee in industry is one which is attracting considerable attention all over the civilized world, but more especially in Canada and the United States. Evidence of this is found in the many commissions and committees appointed by governments, groups of employers and research foundations to make investigation of the facts and report as to possible solutions.

Stated in its simplest terms, the problem with which we are confronted is that every year large numbers of men and women who have worn themselves out in industry reach the age of impaired efficiency, when they become, from an industrial point of view, superannuated. In the majority of cases they reach this age without having saved sufficient to support them during the remainder of life.

This is, of course, not a new problem, but has been present with us in one form or another in all ages. It has, however, been easier of solution under a patriarchal system of society such as existed before the industrial era, than it is under our highly complex mode of life today. The industrial era has set up new conditions and produced new problems. It has dehumanised the old simple processes of production, by crowding men into shops and factories and making them machine tenders, responsible only for one process, or even a part of a process. One result is the degree to which workers have become entirely dependent upon one industry for a means of a livelihood and by crowding into cities have lost the opportunity of producing much of their own food as the rural dweller does.

In addition, the gigantic size to which many industries have grown has resulted in the complete loss of those personal relations which used to exist between employer and employee.

[1] Presented before the Canadian Section meeting, March 13, 1930.

[2] Confederation Life Association, London Life Insurance Company, Mutual Life Assurance Company of Canada, Toronto, Can.

FROM THE SOCIAL VIEW POINT

Considered as a social problem this state of affairs is exercising the minds of a great number of thinking men and women, and some attempts are being made to find a solution through the action of governments. In the Dominion of Canada old age pensions have been introduced in the five Provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and the Yukon and in six states of the United States of America old age pensions have been established. In addition we find that many municipalities, trade organizations and welfare societies are investigating the problem and taking such action as they are able.

Such measures as have been taken can, however, be considered at the best as only palliative, as the problem is too large and widespread for solution along these lines. Such attempts are doomed to failure, if for no other reason than because no funds have been built up out of which to pay annuities and consequently the cost will prove prohibitive if it is attempted to do anything more than take care of the cases of complete destitution in very old age. This aspect is illustrated in the provisions and conditions attaching to the Government old age pension in the Dominion of Canada which fixes the age of 70 as that at which an applicant is pensionable and does not raise the pensioner's income to more than $1 a day under any circumstances, while on the average it pays but 60 cents a day.

THE OLD EMPLOYEE AN INDUSTRIAL PROBLEM

There is a steadily growing volume of influential opinion that this problem of the old employee has been created by the methods of industry and can, therefore, reasonably be considered one for which industry must take the responsibility of finding a solution.

Our industrial system is a partnership between capital as represented by building, machinery, material, etc., and labor. All that the worker is able to bring into this partnership is his labor coupled with some acquired skill and experience. Long ago, it was discovered that machinery and buildings depreciate and eventually wear out. An allowance in cost is always made for this factor and is passed along to the consumer in the price of the finished product.

Just as surely and inevitably the human machine wears out in the course of production and has to be replaced with new. It seems only reasonable that industry should recognize this as a necessary

production expense and in the same way pass on the cost to the consumer.

This is the sore spot in industry today, the collar sore that affects the economic balance and which must be healed or the consequences may be devastating.

As we develop industrially, taking an ever increasing percentage of the population into the ranks of industry, a growing multitude of men and women wear themselves out in service and reach the age of impaired efficiency, or physical inability to continue their work, without having had a reasonable chance to lay aside a sufficient competence to carry them through their declining years. The new recruits strong and vigorous, face life with courage and hope, but have the same fate awaiting them at the journey's end, dependence on relatives or a destitution with which only charity can deal.

The hope for the future not only for the workers, but for the very stability and continuance of the social and economic structure of the National Life depends upon our being able, within reasonable time, to induce industry as a whole to accept the proposition that it is responsible for and alone can satisfactorily deal with the problems of the superannuated worker.

If we do not succeed and this problem of management and administration does not find a solution, then it will emerge again in an aggravated form as a social problem of national dimensions, calling for action by the state and possibly carrying with it the necessity for far reaching changes in the social and economic fabric of our national life.

A SURVEY OF CONDITIONS

If evidence of the need of such provision is desired it can be found on every hand, but one or two illustrations must suffice. An investigation made recently by the National Civic Federation and the Pension Commission of Massachusetts of approximately 31,000 persons sixty-five years of age and older living in industrial cities in the United States disclosed the fact that 30 percent owned no property at all; and 15 percent owned property worth less than $2,000. Of this 31,000 old people, nearly 47 percent had worked for the same employer twenty years or longer, while 55 percent had completed at least fifteen years service.

Worn out in industry 55 percent of these superannuated employees reached the end of the road without a competence in spite of long

continuous service with one employer. This information was obtained from statistics covering eleven cities by methods which are considered satisfactory for securing reliable results.

In the Dominion of Canada we find that the statistics compiled in relation to government pensions show at least 40 percent of the people over seventy years of age have incomes of less than $1 a day.

There are many other such cross-sections of our population available, but these two are sufficient to give some idea of the magnitude and spread of the problem and to point to the urgency of finding a solution.

Over one hundred years ago that prophetic thunderer, Thomas Carlyle, in his essay on "Captains of Industry" warned us that—"Love of men can not be bought by cash payment, and without love men can not endure together. Your gallant battle hosts and work hosts will need to be made loyally yours. They must and will be regulated, methodically secured in their just share of conquest under you, joined with you in honorable brotherhood by other and deeper ties than those of temporary wages."

The deeper ties he had in mind were contentment and loyalty, without which no industrial civilization is safe, and to the securing of which among the workers, industry today must give heed.

A SUGGESTED SOLUTION

In the past industry has attempted to deal with the problem in one of three ways:

1. Old employees have been discharged without further income. This practice has always been considered undesirable and is today discredited because of the bad relations engendered.

2. Transfer the employee to lighter work on pay. This is a very usual method, but has many undesirable consequences. It retains the inefficient on the payroll, slows up production and it can truthfully be said that this method involves paying the cost of a pension plan without reaping the benefits. This feature of hidden cost is illustrated by an analysis of the experience of the British Empire Steel Corporation under their Pension Plan. It was found that out of 360 employees retired on pension in 102 cases pensioners were not replaced and in only 175 cases were new men employed to fill vacancies. Obviously many of these superannuated employees have been kept on the payroll after their usefulness as production units had disappeared.

3. Retire the employee on some sort of income. This is the most approved method and the one with which we have to deal. It has many benefits. It stimulates the whole organization, and by removing the old and impaired worker makes it possible to keep production speeded up. It clears the road to promotion and satisfies the ambitions of the young and vigorous worker. It enhances the reputation of the employer and attracts the best type of employee, for whom long and continuous service becomes a business asset.

For these and other reasons, it is gratifying to find that employers are attracted to the pension system of retiring employees, not for benevolent or charitable reasons, though doubtless they obtain some moral satisfaction from the adoption of such a plan, but for reasons of industrial relations. It is being regarded as a system of insurance affecting production.

THE PENSION METHOD

Assuming the growing acceptance of the retirement method by industry, the urgent question is to decide upon the best way of providing and safeguarding the benefits and securing the maximum in desirable results to both employer and employee. Many methods have been tried, some with very unsatisfactory results. These range from simple thrift plans, through stock purchase plans to full contractual pension plans administered by a life insurance company. In short, it can be said that plans which are optional to the workers, e.g., thrift and stock purchase plans, prove unsatisfactory to the employer, because they do not ensure a complete solution covering all employees, and plans which are administered by the employer, or plans without clearly defined rights to the worker prove unsatisfactory to the employees, because of uncertainty as to the benefits, lack of guarantees behind the promise of benefits, or variation in treatment due to paternalistic control.

This leaves as the only satisfactory method and the only one which has uniformly worked well in experience, that of providing retirement benefits through a life insurance company. And indeed the life companies are peculiarly well equipped to carry on this work. With their gigantic assets, their government controlled investment policy, their experience of annuity business and their organization, they are in a position to give to industry, a service in which every desirable feature of security, economy and adaptation to requirements can be fully met.

WHAT BENEFITS SHOULD BE PROVIDED

The essential idea is that such a plan makes provision for the payment to the retiring employee of an income for the remainder of his life. The age at which retirement is to take place, would, of course, vary somewhat with the particular industry, but general experience has settled upon the normal retirement age for men as sixty-five and for women somewhat earlier, say sixty.

Provisions as to retirement age should be made flexible in order to get the best results, so that, in cases where both employer and employee are agreed that it is desirable, the employee may remain at his work until a later age; and in cases where physical impairment sets in earlier than sixty-five arrangements may be made for the pension payments to begin then, although this would almost certainly have to be on a lower scale than at sixty-five.

The plan should guarantee all benefits bought, absolutely, so that the employees will have confidence that bad business conditions, or change in management of the industry will not affect past accumulations. This is important in view of the history of some inadequately guaranteed plans, where, because of insufficient reserves having been set up, the benefits originally promised the employees have had to be scaled down. We shall refer to this aspect of the question later on.

All contributions made by the employees should be secured to them so that they may obtain a refund of their deposits in the event of their leaving the service of their employer, or so that such deposits may accrue to their estate in case of death before retirement age is reached.

A benefit in case of death added to the retirement benefit much increases its attractiveness and usefulness without greatly adding to the cost. This may be from one to one and one-half years' wages, and is frequently graded according to length of service.

Other benefits which are sometimes incorporated to make the plan complete are: A benefit in case of total and permanent disability, which usually provides for the payment of an annuity to the employee in case of total and permanent disability, and a benefit in case of sickness or non-occupational accident, to cover the hazard of loss of wages and consequent loss of ability to make deposits to the pension fund in case of sickness or non-occupational accident. Workmen's compensation, of course, indemnifies against loss due to accidents while at work.

HOW SHOULD THESE BENEFITS BE PROVIDED?

This question involves the consideration of the amount of benefit to be provided. It is generally admitted that pensions should not be too large, so as to make the cost excessive, but must of course, be large enough.

A well conceived scheme should aim at providing a reasonable subsistence level of income, so as not to remove entirely incentives to personal thrift, and within these limits the amount of pension benefit to be purchased for each employee is best regulated by the two factors which measure the value of his service to his employer, i.e., length of service and wages received. So that the most common formula is to take a definite percentage of wages and multiply it by the years of service to arrive at the pension payable on retirement.

A plan which provides pensions of from 50 to 70 percent of average wages will be found to be very adequate and satisfy all requirements. Such a plan would involve the purchasing of an annuity equal to 2 percent of the aggregate of each year's wages. A maximum and minimum pension might be introduced.

THE PROBLEM OF PAST SERVICE

A factor that always enters into the calculation at the inception of the plan and much increases the difficulty in the case of old established industries is the question of how to take care of the past service of employees on the payroll.

It is necessary to take this into account because in all such cases there will be found to be a fair percentage of employees who are already half way, or further along, towards the retirement age, and who have many years of service to their credit. For them there is not time to accumulate an adequate pension unless some account is taken of past service. For instance, an employee fifty years old would have only fifteen years in which to build up a pension by age sixty-five, and if 2 percent of each year's wages were the basis then at age sixty-five he would have a pension equal to only 30 percent of annual wages. If, however, he had ten years of past service to his credit, and this were taken into account, the pension he would be entitled to at sixty-five would be more adequate. This is usually done on a somewhat smaller scale than for future service and from 1 to 1.5 percent of present wages multiplied by years of past service is considered adequate.

SHOULD EMPLOYEES CONTRIBUTE?

The consensus of opinion is that employees should contribute to their own retirement pensions, the amount of such contributions being usually between 3 and 5 percent of their wages.

Such a policy has many advantages. It makes possible the provision of more adequate benefits than the employer might feel able to provide alone, and under such a contributory scheme the employees usually enjoy contractual rights to the benefits purchased which leads to greater satisfaction and appreciation of the plan.

By far the most important reason, however, for the adoption of the contributary principle is that it involves employer and employee in a piece of cooperative work, and so helps to bring back into industry a sense of personal relations. This is a very valuable contribution to employer-employee relationship problems.

There is another reason which cannot be expressed better than by quoting the words of Mr. J. H. Thomas, Lord Privy Seal, taken from a speech made last November "Anything that makes men and women rely on other efforts than their own, anything that tends to make men and women look to the State for assistance which they themselves ought to give is calculated to destroy and sap that independent spirit which built up the British Race."

WHAT ARE THE COSTS OF SUCH A PLAN?

It is one of the principal features of such a plan that it can be made both actuarially safe and sound and the costs exactly known. In many of the self-administered plans at present in operation this element is lacking. Pensions are either paid out of income, or liabilities are set up on the books and only partially taken care of from year to year. In all such cases trouble looms ahead in the shape of rapidly mounting costs, as is well seen in the case of some of the railroads and some large corporations.

The pension expenditures in table 1 illustrate the tendency of pension costs to increase.

Under such a plan as is outlined above it is possible to set in advance the exact cost in relation to the payroll, and to make each year a closed book, adding the costs for the year to general production cost.

By buying each year an annuity for each employee equal to a definite percentage, say 2 percent of his wages, the transaction is completed, the cost taken care of, and the annuity guaranteed.

This system enables the employer to keep the costs within the ability of the industry to bear them. The figure is rarely a very high percentage of payroll, if the cost is paid from year to year as the service is rendered, although the burden is naturally heavier when a large accrued liability on account of past service has to be met. It is in fact not the cost of a pension service but the cost of delay that creates difficulty. This is, of course, due to the operation of interest

TABLE 1

Pension expenditure

YEAR	ANNUAL PAYMENT FOR PENSIONS, DOLLARS	NUMBER OF PENSIONERS
Canadian Pacific Railway		
1904	80,000	99
1911	80,000	492
1912	125,000	537
1916	125,000	834
1917	500,000	849
1926	600,000	1,403
1928	750,000	1,503
United States Steel Corporation		
1911	281,000	
1921	948,000	
1923	1,448,000	
1925	2,069,000	
1928	3,488,000	
Pennsylvania Railroad		
1900	300,000	
1928	6,083,000	

on each year's liability for past service, and if the accounting is long delayed the result is apt to be disconcerting.

This can be illustrated very simply. We are accustomed to buying a variety of services which add to the amenities of life, and it is usual to pay for these at the time the service is rendered. You, for instance, are supplying a water service, and expecting to collect from the consumer at regular intervals. If some young and newly married man, say twenty-five years of age, came into your office and

asked for your service to be supplied to him, suggesting that instead of paying you in the usual way he let the account accumulate at 4 percent compound interest for forty years until he was sixty-five when he would write you a cheque in settlement, it probably would not appear to be good business to accept his offer. Should you do so, the probability is that you would have to collect from his children, or even his grandchildren, with interest still operating. To take an illustration in figures, a service costing 10 cents a day for six days a week for fifty years, such as for example street car fares, if not paid until the end of the period, would add up to $1,560, but by the operation of interest at 4 percent would require more than $5,000 to liquidate.

TABLE 2

Costs for providing pension benefits

RETIREMENT PENSION AT AGE 65	COST AS PERCENTAGE OF PAYROLL
Equal to 2 percent of average pay multiplied by years of future service, with a provision of 1 percent multiplied by years of past service	9
Death benefit equal to 1 year's salary	1
Addition of total and permanent disability benefits to retirement pension	0.5
Sickness and accident indemnity, equal to one-half wages	1

It is just in this way that the accrued liability for pension service grows and if the amount due each year is not set aside and invested properly, then the liability will increase until it is formidable.

At age sixty-five the normal expectancy of life for a man is twelve years. Let us assume we are going to pay him a pension of $50 a month for these twelve years, or $7,200 in all. We can guarantee this if we have $6,000 cash at age sixty-five and can be sure of 4 percent interest. So that the problem is a simple one, that is, merely to accumulate $6,000 by the time the man is sixty-five years old.

Now if we start when he is fifteen years old this can be done by making an annual deposit of approximately $38.00, at twenty-five the deposit would have to be $61, at 45, $194, but at sixty-five we must put down the whole of the $6,000. These approximate figures assume 4 percent interest.

The Life Insurance Companies are prepared to meet the difficulty

of this accrued liability by enabling the employer to accept the obligation and retire it over a period of years, up to twenty or thirty. This means that to the normal cost to the employer of present service will be added during the retirement period a percentage to pay off the accrued liability, and, of course, once this feature of the problem has been dealt with it never recurs.

Approximate costs for the provision of the benefits outlined are shown in table 2. They are based upon average cases and are only intended as a guide. These costs can be divided between employer and employee as seems most expedient.

RESIDUAL ALUM IN NORTH CAROLINA FILTERED WATERS[1]

By J. W. Kellogg[2]

About thirty years ago alum was first used as a coagulant for precipitating the turbidity in muddy waters and for more than twenty years it has been used generally for this purpose. At first the dosage was mainly by rule of thumb and the methods of application were quite rude. Twenty years ago the rule was to use enough alum to clear the water without producing an acid water, but in some instances operators used a "little" soda-ash or lime to "counteract the acidity" produced by the breaking down of the aluminum sulfate. During the past few years we have taken immense strides in the art of water purification, especially in the matter of design of the water treatment plants and in the correct dosage of the raw water. The chemical treatment of various waters has been studied with a view toward improving the finished water and in a saving of the chemicals used. The problem of calculating the amounts of chemicals necessary to produce a clear effluent and at the same time to utilize all the alum applied and effect complete removal of the alum has been carefully studied and solved in many water treatment plants.

Since the iso-electric point for the coagulation of all waters by sulfate of alumina is not the same, this point should be determined for each water and adjustment made by adding either lime or acid. We may lose the coagulating effect of some of the applied alum by failing to precipitate it, allowing it to pass through the filters in solution, but by using lime or soda-ash to raise the alkalinity, or on the other hand acid or acid salts to increase the acidity, the iso-electric point may be reached and complete precipitation accomplished. Economic considerations will determine the advisability of the use of such means to effect the complete precipitation of the alum. In cases where secondary lime treatment is practiced to prevent corrosion a solvent action on the floc may be produced with the result that the

[1] Presented before the North Carolina Section meeting, October 14, 1930.

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effluent will contain more alum than the raw water plus that addded as alum.

The methods of measuring the amounts of alum in water have also been improved. In a manual printed in 1906 two methods were prescribed for estimating the amount of alum present in the water, the old "logwood" method and the hematoxylin method, both of which were inaccurate. The Standard Methods printed in 1912 stated that the logwood method was not recommended, and advised the determination by means of titration of the acid present, using a solution of sodium carbonate with lacmoid or erythrosine as an indicator. By this method a rough estimate of the alum present could be made in acid water. Between 1908 and 1924 tests were made in the State Laboratory of Hygiene to determine the alkalinity of all samples from filter plants, and if the sample of water was found to be acid the hematoxylin test (as then known) was applied, and in almost all cases (in acid samples) alum was found to be present. No attempt was made to measure the amount of alum, and no tests for alum were made in alkaline samples, as the assumption was made that in these all the alum had been precipitated. A precipitate of aluminum hydrate was sometimes noted and reported as such. Such an occurrence was due either to an improperly working filter or to the precipitation of the alum after it had passed through the filter in solution.

In March, 1924, Wm. D. Hatfield published a paper (Ind. and Eng. Chem., 16: 3, p. 233) giving an account of a new method of estimating the amount of soluble aluminum compounds present in water and during that same year routine tests were begun in our laboratory to determine the amount of soluble alum in all alum treated waters. About the same time routine determinations of the pH (hydrogen-ion concentration) were begun and since that time both these tests have been made on all treated waters.

Much credit is due George F. Catlett for his efforts to get the filter operators to improve their methods of alum dosage. By making the "jar test" and then reproducing the experiment on a plant scale he enabled the operator properly to adjust the dosage. The technique of the test is described in "Operation of Water Filtration Plants" Special Bulletin No. 211 published by the North Carolina State Board of Health. In this test measured amounts of alum and soda (or lime) are added to known amounts of the water in question and the jar in which the floc first appears is taken as the optimum for that water.

The pH of this treated water is read and the dosage of chemicals added to the raw water is made to conform to this optimum. It has been found that when the water is thus properly treated, provided proper mixing chambers, sedimentation basins, etc., are present, the alum will be practically all precipitated, and the floc left in the basins or deposited on the filter beds. It follows, of course, that if for any reason floc goes through the filter, and secondary lime treatment is added to prevent corrosion, this floc may be redissolved and thus soluble residual alum will result in the finished water.

This paper is not an effort to describe methods of dosage of water, but to give the operator an idea of the possibilities of producing an alum-free water. The test for alum as used in our laboratory is described in an abstract of Hatfields paper, printed in the July, 1924, issue of THE JOURNAL.

Satisfactory tests for presence of soluble aluminum in waters through use of hematoxylin may be had only within comparatively narrow zone of hydrogen-ion concentration, pH 8.0 to 8.5. The hematoxylin-alumina color compound will not form below pH 6.0. Above pH 8.5 the color fades rapidly. Between pH 6.5 and 7.5 a relatively permanent, but slow forming color develops. Waters adjusted to pH 8.0 to 8.5, if containing soluble aluminum, will produce a blue color, which upon acidification with 30 percent acetic acid, changes to purple. The excess hematoxylin present changes to yellow, thereby presenting variations from yellow through brown to purple, depending upon the quantity of aluminum present and excess of indicator. The procedure calls for buffering 50 ml. (cubic centimeter) of water with 1 ml. saturated ammonium carbonate aqueous solution to obtain a pH of about 8.2. Add 1 ml. of a 0.1 percent aqueous solution of hematoxylin solution, mix and allow fifteen minutes for color development. Acidify with 1 ml. 30 percent (glacial) acetic acid and compare with standards of known aluminum content treated in like manner.

VARIATION IN WATERS IN NORTH CAROLINA

In North Carolina there are three general classes of surface waters, the Eastern (colored), Piedmont and Western, each of which as a class flocs at or near the same optimum. In each class, however, we find that different waters are individually different, and thus at each water treatment plant, the optimum for that water must be determined. Differences of construction also occur in each plant and these may cause necessary variations in treatment and dosage to insure a clear effluent free from alum. In the laboratory tests we have made on water samples, we find certain plants which uniformly produce a water practically free from alum, as we find those which

uniformly produce a water free from intestinal bacteria. In others lapses occur in both respects, although the percentage of these has decreased enormously during the past six years.

Among the colored waters which coagulate at or near pH 4.4 none has been successfully treated as yet, so as to remove both the color and leave an alum-free water. Among the Piedmont waters several plants which uniformly produce an alum-free water are worthy of notice.

In our tabulation we have empirically taken three points of division. The first includes those samples showing no alum which are marked "Zero." The second includes those determinations between 0.01 and 0.04 p.p.m. The third covers all those above 0.04 p.p.m. In our tests no amounts greater than 1.0 p.p.m. were recorded, although the test might indicate more than this amount. The personal equation must be taken into account in the readings, as with any such titration where the reading depends upon the matching of colors. Especially in the readings below 0.05 p.p.m. is this true, for the differences are so slight that in the standards the 0.00 p.p.m. tube will often appear darker than the 0.01 tube, etc. We do not claim that all the alum should be precipitated in each plant at all times, and can set no arbitrary limit above which point the amount of alum might be considered objectionable. The record of well regulated filter plants shows that it is possible to average well below 0.05 p.p.m. at all times, but the records also show that during the winter time the amount of residual alum is somewhat greater due to the low temperature retarding the chemical reactions.

Even though there may be no physiological reasons why a small amount of alum should be harmful to the human mechanism there are certain classes of industrial plants which require an alum-free water, and each filter plant should strive to produce such a water. One source of complaints because of the presence of soluble alum is from the managers of bottling plants, where it has been found that the soluble alum is precipitated in the bottled drinks, forming an objectionable sediment.

Table 1 showing the results of laboratory tests for alum on nine representative filter plants covers a period of five years. On one plant the data cover four years and on another only three years. On the balance of the plants the period is for two years, with the exception of eleven which were not using alum as a coagulant during 1925. The period marked 1929 is in all cases from July, 1929, to

TABLE 1

Residual soluble alum in filter effluents

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01–0.04	LESS THAN 0.05		AVERAGE
					Number	Per cent	
Albemarle	1925–29 5 years	63	34	18	52	82	0.034
Apex	1926–29 4 years	66	15	20	35	53	0.098
Asheboro	1925–29	74	29	14	43	58	0.12
Badin	1925–29	62	24	26	50	80	0.021
Belmont	1927–29 3 years	37	14	10	24	65	0.042
Bessemer City	1925–29	66	29	20	49	75	0.025
Burlington	1925–29	61	37	12	49	80	0.021
Chapel Hill	1925–29	73	39	14	53	74	0.06
Charlotte	1925–29	58	34	16	50	86	0.014
Clyde	1925–29	50	25	17	42	84	0.02
Laurinburg	1925–29	65	3	4	7	10	0.33
Lumberton	1925–29	79	0	0	0	0	0.68
Proximity	1925–29	140	66	40	106	75	0.033

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01–0.04	LESS THAN 0.05	HIGH	AVERAGE	TWO-YEAR AVERAGE
Concord	1925	12	9	3	12	0.03	0.006	
	1929	14	9	2	11	0.07	0.015	0.01
Cliffside	1925							
	1929	13	8	4	12	0.08	0.011	
Cramerton	1925	12	10		10	0.1	0.012	
	1929	12	3	6	9	0.08	0.023	0.017
Cullowhee	1925							
	1929	5	3	1	4	0.07	0.018	
Davidson	1925	13	7	4	11	0.2	0.026	
	1929	12	7	3	10	0.07	0.012	0.019
Dunn	1925	16	3	9	12	0.2	0.04	
	1929	12	7	4	11	0.08	0.012	0.026
Durham	1925	12	5	3	8	0.8	0.114	
	1929	14	5	4	9	0.1	0.03	0.072

TABLE 1—*Continued*

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01–0.04	LESS THAN 0.05	HIGH	AVERAGE	TWO-YEAR AVERAGE
Elizabeth City	1925	13	0	0	0	1.0	0.8	
	1929	12	2	0	2	0.8	0.21	0.5
Elkin	1925	13	6	5	11	0.5	0.054	
	1929	12	3	1	4	0.3	0.09	0.072
Fayetteville	1925	16	5	3	8	0.3	0.07	
	1929	12	2	1	3	0.3	0.1	0.09
Forest City	1925	13	8	2	10	0.3	0.04	
	1929	12	7	3	10	0.07	0.014	0.027
Franklinton	1925	6	2	3	5	0.05	0.02	
	1929	15	10	5	15	0.04	0.008	0.024
Gastonia	1925	12	7	4	11	0.3	0.032	
	1929	13	6	3	9	0.3	0.047	0.04
Goldsboro (City)	1925	20	1	1	2	1.0	0.392	
	1929	13	3	1	4	1.0	0.38	0.386
Goldsboro (State Hospital)	1929	12	1	1	2	0.8	0.18	
Greensboro	1925	13	7	3	10	0.3	0.057	
	1929	13	7	3	10	0.1	0.02	0.038
Greenville	1925	19	8	6	14	1.0	0.21	
	1929	12	4	5	9	0.2	0.041	0.14
Hamlet	1925	32	3	3	6	1.0	0.46	
	1929	11	2	1	3	0.4	0.12	0.29
Henderson	1925	29	7	5	12	1.0	0.23	
	1929	12	4	4	8	0.3	0.08	0.15
Hertford	1925	16	1	0	1	1.0	0.7	
	1929	12	0	0	0	1.0	0.66	0.68
Hickory	1925	14	2	4	6	1.0	0.2	
	1929	12	2	1	3	0.3	0.1	0.15
High Point	1925	16	8	6	14	0.05	0.012	
	1929	11	6	3	9	0.1	0.016	0.014

TABLE 1—*Continued*

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01–0.04	LESS THAN 0.05	HIGH	AVERAGE	TWO-YEAR AVERAGE
Kernersville	1925							
	1929	12	0	1	1	1.0	0.68	
King's Mountain	1925							
	1929	12	4	5	9	0.08	0.026	
Leaksville	1925	13	7	5	12	0.3	0.031	
	1929	12	6	2	8	0.08	0.0222	0.026
Lenoir	1925							
	1929	12	5	3	8	0.08	0.025	
Lexington	1925	12	8	4	12	0.02	0.006	
	1929	13	8	3	11	0.1	0.016	0.011
Lincolnton	1925							
	1929	13	4	7	11	0.1	0.021	
Louisburg	1925	17	9	7	16	0.08	0.014	
	1929	13	4	2	6	1.0	0.26	0.137
Mebane	1925	12	7	4	11	0.1	0.013	
	1929	13	8	4	12	0.2	0.02	0.016
Moncure	1925	2	1	1	2	0.05	0.025	
C. P. & L.	1929	12	9	2	11	0.2	0.018	0.021
Monroe	1925							
	1929	13	5	2	7	0.8	0.14	
Mooresville	1925	11	7	1	8	0.2	0.032	
	1929	13	6	5	11	0.05	0.015	0.023
Mt. Airy	1925	13	9	3	12	0.06	0.01	
	1929	12	4	5	9	0.08	0.02	0.015
Mt. Holly	1925	4	2	1	3	0.05	0.02	
	1929	12	3	8	11	0.1	0.021	0.02
Newton	1925	13	6	5	11	0.3	0.034	
	1929	11	5	5	10	0.2	0.028	0.031
North Wilkesboro	1925	13	8	1	9	0.3	0.04	
	1929	13	6	3	9	0.2	0.033	0.036

TABLE 1—*Continued*

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01-0.04	LESS THAN 0.05	HIGH	AVERAGE	TWO-YEAR AVERAGE
Oxford	1925	4	2	1	3	0.3	0.08	
	1929	17	5	8	13	0.2	0.037	0.058
Raleigh	1925	59	29	18	47	0.2	0.024	
	1929	61	10	22	32	0.3	0.05	0.037
Reidsville	1925	16	5	3	8	1.0	0.22	
	1929	12	5	5	10	0.05	0.015	0.117
Rockingham	1925							
	1929	13	1	0	1	1.0	0.45	
Rocky Mount	1925	14	4	2	6	1.0	0.18	
	1929	13	3	3	6	1.0	0.19	0.185
Roxboro	1925	12	9	1	10	0.05	0.01	
	1929	22	15	3	18	0.08	0.016	0.013
Rutherfordton	1925	12	4	7	11	0.05	0.017	
	1929	12	6	6	12	0.03	0.007	0.012
Salisbury	1925	13	8	2	10	0.5	0.063	
	1929	13	4	6	10	0.08	0.023	0.043
Samarcand	1925	5	0	0	0	1.0	0.72	
	1929	10	0	0	0	0.9	0.37	0.54
Sanatorium	1925	21	0	0	0	1.0	0.7	
	1929	12	0	0	0	1.0	0.4	0.55
Sanford	1925	17	6	5	11	1.0	0.16	
	1929	14	8	4	12	0.2	0.024	0.092
Shelby	1925	16	5	4	9	1.0	0.32	
	1929	12	5	4	9	0.3	0.042	0.181
Smithfield	1925	16	6	6	12	0.3	0.05	
	1929	12	5	5	10	0.3	0.041	0.045
Southern Pines	1925	22	5	2	7	0.8	0.18	
	1929	12	0	0	0	0.7	0.18	0.18
Spindale	1925							
	1929	12	7	2	9	0.2	0.03	

TABLE 1—*Concluded*

TOWN	PERIOD	NUMBER OF SAMPLES	ZERO	0.01–0.04	LESS THAN 0.05	HIGH	AVERAGE	TWO-YEAR AVERAGE
Statesville	1925	12	9	3	12	0.02	0.004	
	1929	12	8	2	10	0.1	0.018	0.011
Tarboro	1925	12	2	1	3	1.0	0.27	
	1929	13	2	5	7	1.0	0.18	0.22
Thomasville	1925	12	10	2	12	0.02	0.002	
	1929	13	9	1	10	0.08	0.018	0.01
Troy	1925	4	1	0	1	0.8	0.4	
	1929	15	5	5	10	0.09	0.028	0.214
Tryon	1925							
	1929	14	2	4	6	0.1	0.054	
Wadesboro	1925	12	7	1	8	0.5	0.08	
	1929	12	5	4	9	0.07	0.018	0.049
Wake Forest	1925	17	7	2	9	0.8	0.19	
	1929	12	4	3	7	0.08	0.032	0.111
Washington	1925	16	7	4	11	1.0	0.15	
	1929	15	0	0	0	1.0	0.7	0.425
Weldon	1925	29	12	9	21	1.0	0.085	
	1929	13	7	4	11	0.08	0.014	0.049
Wilmington	1925	13	4	2	6	1.0	0.19	
	1929	14	0	0	0	1.0	0.34	0.26
Wilson	1925	17	1	0	1	1.0	0.42	
	1929	13	2	2	4	0.5	0.21	0.31
Salem	1925	12	6	4	10	0.5	0.067	
	1929	12	7	2	9	0.08	0.023	0.045
Winston	1925	13	6	5	11	1.0	0.088	
	1929	13	9	1	10	0.3	0.034	0.061
Zebulon	1925	22	8	5	13	1.0	0.22	
	1929	12	2	1	3	1.0	0.39	0.3

June, 1930, inclusive. In this way we may compare the results of tests on samples during the five-year period during which tests for alum have been made. The tabulation includes results on samples from 79 filter plants, and many instances of proper and of improper dosage are evident. Among those which may be classed as successful in producing an alum-free water are: Albemarle, Badin, Bessemer City, Burlington, Charlotte, Concord, Cramerton, Davidson, High Point, Lexington, Mebane, Mount Airy, Mount Holly, Roxboro, Rutherfordton, Statesville, Thomasville, and others which have a record nearly as good. On the other hand, several do not as a rule show less than 0.1 p.p.m. which might be enough to cause trouble where an alum-free water is desirable for use in some classes of industrial plants. These will not be mentioned by name. Several plants have made improvement in the five year period and these are to be commended. In some cases the difficulty seems to be due to faulty construction, but mainly in improper methods of dosage. It may be noted that our method of estimating the amount of alum has been checked by F. O. Baldwin, Chemist in Charge, at the Filter Plant, Richmond, Va. and that our results checked fairly well at the time he visited our laboratory.

Detailed instructions for making the "jar test" as well as for making the Hatfield test for alum are included in this paper.

APPENDIX 1

THE "JAR TEST"

Solution (A) Alum 1 drachm to 16 ounces distilled water.

(B) Soda or Lime 15 grains to 16 ounces distilled water.

The test is made by measuring 1 quart of the raw water to be tested into each of six clear glass jars, numbered 1 to 6.

Measure varying amounts of the solutions A and B.

Stir the water in the jars vigorously and allow to stand until the floc appears.

Observe the jar containing the smallest amount of alum and the proportion of alkali which gives the quickest floc.

The alum solution is of such strength that each milliliter (cubic centimeter) put in 1 quart of water will be equivalent to one-half grain per gallon or 7 pounds for each 100,000 gallons water.

The soda ash is one-fourth as strong and each milliliter to a quart of water is equivalent to one-eighth grain per gallon (two parts per million) or $1\frac{3}{4}$ pounds to each 100,000 gallons water.

By using various combinations of solutions the optimum may be arrived at.

See Example, Special Bulletin, No. 211, North Carolina State Department of Health.

APPENDIX 2

HEMATOXYLIN TEST FOR SOLUBLE ALUMINUM COMPOUNDS

(Wm. D. Hatfield, Ind. & Eng. Chem., 16: 3, p. 233)

Reagents

1. Dissolve 0.1 gram hematoxylin crystals in 100 ml. boiling distilled water. This solution is stable (in the dark) for about two weeks.

2. Saturate 500 ml. distilled water with ammonium carbonate and keep in g. s. bottles with an excess of crystals.

3. A 30 percent solution of acetic acid.

4. Standard ammonium alum solution. 0.8366 gram ammonium alum dissolved in distilled water and diluted to 1 liter. One milliliter of this solution in 50 ml. distilled water equals 1 p.p.m. Al. Use also a 1:10 dilution of this standard.

Procedure

To 50 ml. sample water in tall form Nessler tube, add 1 ml. ammonium carbonate solution and 1 ml. hematoxylin solution. Mix by inverting tube. Allow to stand fifteen minutes for maximum lavender color to develop, and then acidify with 1 ml. 30 percent acetic acid.

Compare the color formed with that of standard color tubes which were prepared in exactly the same way and at the same time by using standard ammonium alum solution and distilled water to represent from 0.00 to 1.0 p.p.m. Al.

With concentrations less than 0.15 the color is compared against white paper through the length of the tube, while with higher concentrations the color is best compared through the sides.

Note. The advantage of this method is said to be that all comparisons are made at a standard pH, namely 4.5.

See Jour. A. W. W. A., July, 1924, p. 943.

PROPER FILTER OPERATION AND MAINTENANCE[1]

By Harry E. Jordan[2]

Many papers and even books have been written to this title. Worthwhileness in this case will be evidenced by brevity. Moses is presumed to have brought down a moral code of ten paragraphs. What are the ten things of major importance in operating a filter plant?

1. "Don't say it—write it." Not only directions for operation, but also results of operation. *Don't guess.*

2. Know the immediate watershed. Resist any tendency to add to pollution of stream. Coöperate with Fish and Game organization.

3. Observe and *record* physical condition of raw water hourly. Check equipment for feeding coagulant at least hourly.

4. Lighten the load for final chlorination by pre-chlorination when needed. It would seem worth while to prechlorinate all waters showing 50 percent coli findings in 10 cc. quantities prior to final chlorination. This presumes a filter effluent turbidity less than 0.5 p.p.m. While the ability of modern chlorine equipment to give continuous service is much greater than in the early days, it is vital that too great a responsibility be not placed upon a single step in the purification process.

5. Generally a coagulated water that filters clear through coarse paper just after treatment, will settle well and filter clear. Whether it is necessary so to coagulate that bottle samples will settle clear and sparkling is questionable. It is certain that the turbidity of the settled water should seldom exceed 25 p.p.m.

6. The filter material should show no coarse particles at surface; contain few or no "mud balls;" and be level when dewatered.

A ball of sand from any point below the surface layer should fall apart when released from pressure. Any wash rate that does not freely float the sand layer is inadequate.

7. Effluent turbidities should rarely be higher than 1 p.p.m. The old custom of recording O turbidity on the filtered water is not true.

[1] Presented before the Indiana Section meeting, March 20, 1930.

[2] Filtration Engineer, Indianapolis Water Company, Indianapolis, Ind.

Under the best regulated conditions, the non-softening filter plant will produce a water carrying ±0.25 p.p.m.

8. Effluent chlorination must be handled on an "Excess Chlorine" basis. An adequately prepared and properly filtered water with 0.1 p.p.m. chlorine thirty minutes after chlorination can be depended upon to meet the Treasury Standard. These tests should be made at least hourly. They can be made by any man who has intelligence enough to be trusted around a filter plant. They can be made at any hour, and the result of the test, without reference to anything but standard operating tables, should verify the correctness of the current rate or cause a change to another rate.

9. Men, machinery and structures about a water plant should be clean. Uniform clothing is valuable. Paint is always useful. Brooms and mops are made to use, in corners as well as elsewhere. A dirty water plant operated by frowzy men is probably producing an unsatisfactory water.

10. Nothing but safe water is permissible. Whatever other factor in good water quality may be imperfectly handled, safety must never even be seriously questioned.

A personel that has common sense, ability to follow orders and even a minimum of pride, will so operate a plant as to produce a water of unquestioned safety. If one group cannot do that, they should make way for others who will. By the same token, any city official responsible for the discharge of a competent filter operating staff is as guilty of malfeasance in office as if he had taken public funds.

Good service in a water utility deserves to be continuous service.

SOME OBSERVATIONS ON THE WATER WORKS BUSINESS[1]

By George H. Fenkell[2]

Everyone engaged in the water works field is concerned with satisfying his employers with his services; advancing the art of water works engineering and management; in dealing with subordinate employees sympathetically and helpfully; and in receiving fair pay for the work that he performs. While from this statement it may appear that there are four objectives; anyone of these seldom affects one of these interests alone. There are few matters that are of interest only to the employer, the employee, or the scientist, for usually any action that proves advantageous for one will work well for all.

EMPLOYEE PROBLEMS

The management of a private utility solves the question of selecting employees for itself with freedom of action and in the manner that it finds will give the best results, but with municipal works the method of selection of employees becomes of prime importance, because of the baneful methods and influences that may creep in when no specific method for employment is prescribed by law. The trained employee desires to secure his position through fair and honest competition and wishes to maintain it in a continuous and extended manner. There is increasing effort to fill positions through competitive examinations or with due regard to the training and experience of the applicants, and this has led quite generally to the adoption of some form of Civil Service selection and employment. An examination of the subject will show that there are many variations in the details of administering Civil Service laws, but the fundamental law which this form of employment recognizes is that an honest endeavor shall be made to employ, promote and continue in service those who are best qualified to fill the positions in question.

In all matters relating to employment, including the filling of posi-

[1] Presented before the California Section meeting, October 30, 1930.

[2] President, The American Water Works Association; Superintendent and General Manager, Board of Water Commissioners, Detroit, Mich.

tions, promotions, demotions, and length of service of employees, it is essential that there be freedom from political interference. The selection of employees as a reward for political services rendered has generally proven unsatisfactory as far as the community served is concerned. Through the use of Civil Service laws honestly and fearlessly enforced, a faithful employee may expect to continue his labors without being affected in his work or employment because of his political or religious opinions.

The employee wishes to obtain reasonable compensation for the work he performs. He usually has little to say when his rate is determined, and wide differences of opinion will be found to exist with any case that may be taken under examination. The employer usually settles upon a rate that is the lowest that he can use and secure the services that he needs for the time being; while the employee, realizing that he is underpaid, and having no data that are germane, bases his plea for an increased salary on the cost of living as he or others find it. The observation that the speaker wishes to make on this interesting subject is that he believes that a man is generally rated by his fellow citizens according to the salary which he receives or the amount of money that he has been able to accumulate. The water works man desires better recognition by the public for the services he performs and it seems reasonable to conclude that the test of any method that may be employed to obtain better recognition for this work will be found reflected in his income.

The large and progressive public utilities have placed in force quite generally some system for old age pensions, and some cities have adopted a similar method for relieving distress in old age in municipal departments.

A very satisfactory method that has been tried and which has proven quite satisfactory, provides that an old age pension fund shall be established through contributions made both by the department and by the employees.

It is not long since the condition prevailed by which an injured employee, without funds, was entirely at the mercy of the management of the department with which he was connected. More recently, however, a number of states have placed laws in effect which provide for the payment to the injured of regular and fairly adequate sums and for the cost of medical service.

The use of group life insurance has been extended greatly in large manufacturing and industrial concerns, but as far as the speaker

is informed little progress has been made in securing this form of insurance in municipal departments. The insurance regulations require that a portion of the cost for this service shall be borne by the management. Since some city charts at least forbid the use of public funds for insurance purposes, it would seem that the most promising line of procedure is to endeavor to make such insurance available for municipal use by effecting a change in the insurance regulations.

PROGRESS IN THE ART AND IN THE MANAGEMENT OF WATER WORKS OPERATION

The art of water works activities is changing so fast that it is only with difficulty that one can expect to keep informed on the latest practice and methods. Because of this the water works man desires financial support in obtaining the various publications that relate to his work, in attending technical meetings, and in engaging in society and committee work relating to the subjects in which he is interested.

The water works executive is interested in water rates. The water rates that are in force have been adopted frequently without regard to the needs of the department. It is necessary that adequate water rates prevail so that by economical administration the department may be maintained in a thoroughly good working condition and that the water system may be extended to provide for the needs of a growing community. Economies are much more easily effected with a private company than with a municipal department. The latter, during times of good and sufficient employment, may be depended upon to make an earnest endeavor to effect economies and put in force good business methods, but as soon as employment falls off and the placing of those without work on public projects is demanded, it becomes necessary to abandon some of these well conceived economical methods and proceed with the thought of making work for the jobless rather than of effecting savings for the department. In the levying of the income tax, the Federal Government maintains that the function of the water department is proprietary. The water works man believes that the function of the department as now operated is at least partially governmental. He desires that the methods employed in his department be those used by the privately owned public utility as far as possible.

The management of a water department believes that it should

collect and disburse its own funds. So long as this is done it may be expected that these funds will be used solely for the improvement and operation of the water system. Not infrequently, however, these funds are used for purposes for which they never were intended, with the consequent result that the water department is allowed to shift for itself as best it can. The idea that water funds may be used for various public purposes is not a new one, for we find it in use in Europe as well as in this country. Without doubt the use of water meters has had much to do with making water departments self-contained financially, for wherever careful study is given to the use of water meters, consideration will also be given to the use of equitable water rates and the adoption of just methods for the use of funds collected from the sale of water.

In American cities, and when the speaker refers to American cities he includes the cities of Canada, it has generally been assumed arbitrarily that the function of the water department begins with the source of supply at or near the intake works and ends with the consumer's water tap. This seems to be an arbitrary arrangement, for it is probable that the water department could be extended to cover a portion or all of the sewerage system as well. Were the water service extended to include the administration of the affairs of the sewerage works it is not unreasonable to suppose that the water rates would be increased to such an extent that the rates from the sale of water would be sufficient to build and maintain the sewers. There has been no agitation by water works operators to effect such a change, but laws have been enacted which would make this change possible in certain states. As cities find it more and more difficult, because of bonding limitations, to secure funds for projects that are entirely governmental in character, and as the absorption of a sewer system by a water department would probably make it possible for the municipality to issue general improvement bonds to a greater extent, it may be expected that more will be heard on this subject from those whose duty it is to finance public improvements.

Many cities now budget all of their financial needs for at least a year in advance. The work that the preparation of a budget entails is considerable, but it is favorably regarded by those that have given this method a fair trial.

Few departments are able to give the engineering problems that arise the amount of careful study that they deserve and that must be carried on in order that the best possible results may be secured through the use of their regular engineering staff. While an organ-

ization may and often does have the engineers who are qualified to design and build in a good way, the amount of routine work that comes to hand day by day is usually so great that the time needed for special work is not available. To fill in this deficiency is the province of the specialist or the consulting engineer, and it is probably fair to say that the operating engineer does not usually appreciate the advantage that will accrue to him and to his department through the employment, on occasion, of the specialist.

Many of those engaged in the operation of water plants fail to recognize the fact that there is still much to be learned in every line of their work. The amount of time that can be given to experimental and research work is limited, but data come to hand not infrequently that would be of great value to the brother operator were it collected and placed in form for use by others. Nearly every method that is used is borrowed from someone else and one owes it to the other to make available the result of investigations and the adoption of new methods. Steel water pipe is now in quite common use and yet there is no uniformity in specifications for painting or coating such pipe; the value of and the methods to be employed to secure the advantageous use of reservoirs and stand pipes is not well understood; strenuous efforts are being made to find ways for lessening the color and taste in water, and while great advances have been made in the knowledge of this subject, there still remains much work to be done. Many years have elapsed since Allen Hazen pointed out the value of soft water to a community, but the amount of water softened at this time to improve municipal supplies is not great. The capacity of a system to deliver water at each and every point within its limits can easily be determined by means of a hydrant flow survey, and yet this simple method of operation is only occasionally used. The causes of many of the breaks in cast iron water mains are never explained; the amount of rainfall and run-off data available for streams, particularly at flood time, is meagre in many cases. The laws that apply to the operation of a coagulation basin or a sedimentation basin, either with or without the addition of chemicals to the water are not well understood and the design of such basins generally depends on so-called judgment rather than on carefully determined facts. The writer could go on at length pointing out unsolved problems on which there is need for experiment and research. This situation is particularly interesting when one remembers that there is no water plant, no matter how small, or how simple, in which it is not possible to secure valuable information concerning some one of these problems.

WHAT CAN THE INDIVIDUAL CONTRIBUTE?

To those who are making the water works business their life work, and in view of the fact that methods of procedure in all scientific lines are changing so rapidly, the question may well be asked:—What can I do, outside of the regular work in the department, to improve myself in the line of my chosen endeavor? The technical training now offered by the universities is excellent and may be expected to improve. The faculties of these great institutions have given such consideration to the improvement of their curricula and while there may be differences of opinion regarding some of the phases of this work, it must be conceded that the graduates today are well equipped to grapple with the subjects they may expect to encounter. That portion of the press which concerns itself with water works affairs deserves to be congratulated on the thoroughness with which it covers the many subjects involved. The proceedings of the American Water Works Association and of the New England Water Works Association are well edited and are invaluable to those engaged in water works affairs. In the course of the proceedings of the four founder engineering societies, subjects are frequently brought under discussion that are also of interest and should be given careful study. In addition to the publications which will be used for reading and for reference purposes, it is quite necessary that those who have a common purpose be given an opportunity to meet together from time to time so that the members may exchange views and learn at first hand the experiences of others. Meetings such as this give that opportunity, and the officers of this California Section are to be congratulated on the excellent program that has been arranged. No one can attend this meeting without profit to himself and to the interests he represents. Each member should be urged to take part in the meetings he attends through the presentation of a carefully prepared discussion. The American Water Works Association has in the past held only one regular meeting each year. The constitution now in effect makes it possible to hold more than one, but the decision to do so will depend upon the demand that is made upon the Association for meetings by cities that can furnish satisfactory hotel accommodations. The administration of the affairs of the Association is controlled by directors chosen geographically, and the speaker, on behalf of the Board of Directors, invites the California Section to suggest ways and means for securing a larger membership for this section and for giving better and further service to the members who are residents of the State of California.

THE DEPRECIATION YARD STICK[1]

By Harry Boggs[2]

Old Man Depreciation has probably been cussed and discussed more than any other individual subject in the accounting category.

This is probably because he is the most consistent and persistent collector in the world. He leads the tax collector for thoroughness of performance, because while you may be able to conceal a part of your property or obtain a low valuation, you cannot fool Old Man Depreciation. You may ignore him but you can wager your last dime that he will not ignore you. You may refuse to recognize him and may leave him out of all of your calculations, but he will be your constant companion just the same.

Should you ever reach that point where you are sure you can get along without him, then you have reached that depth of sublime ignorance that precedes a financial tumble. You may think you can fool him, but eventually time will prove that you are the one who has been wearing the dunce cap.

I feel that you all agree with me that depreciation is just as necessary an operating expense as labor or fuel, and no financial statement can honestly show a true net profit unless proper provision has been made for depreciation.

I do not know how many of you are familiar with the now famous Maryland or West case handed down by the Supreme Court of the United States on January 6, 1930, under the title of "The United Railways and Electric Company of Baltimore, Versus Harold E. West, et al." This highest authority says that depreciation should be calculated on a basis of the present value instead of the original cost. The following is quoted from the decision:

"It is a settled rule of this Court that the rate base is the present value, and it would be wholly illogical to adopt a different rule for depreciation.

Of course, this decision will no doubt prove of great value to the owners of some public utility properties, but it also may prove of

[1] Presented before the St. Louis Convention, June 6, 1930.

[2] The Indianapolis Water Company, Indianapolis, Ind.

considerable detriment to the owners of other public utility properties, as there is considerable dynamite concealed in it that may not be apparent on the surface, but which can be learned only by an intelligent study of what the future holds in connection with the application of this rule.

The principal battle ground in the matter of administration of regulation is whether or not rates are confiscatory. Up to the present time the practical application of the test in so far as the rate base is concerned, has been based principally on cost of reproduction depreciated as the major factor in arriving at the present value, and now the next step would seem to be to base the determination of the cost of exhaustion of a plant upon the present value theory. If this view is correct the determination of the Courts in future cases may become more and more speculative and the practical outcome will depend largely on the skill of professional advisers of the two sides of the controversy.

The first question that enters the accounting mind is—"Just how can this method be actually applied in the practical operation of a bookkeeping system?" and thereupon follows a series of mental gymnastics that is certainly interesting.

In order to attempt to arrive at some of the answers, let us ask ourselves a series of questions somewhat along the following lines:

What is meant by present value? Does it mean the value as of today or the present value as at some future time when a certain unit of property is to be replaced in ten or more years from now?

If today's present value is to be taken, will that value remain unchanged for a period of future years? If past history is taken as a criterion we know that values are constantly changing, so we are fairly certain of the fact that today's value will not be the value at a future time. Therefore, if our calculations for future replacements are based on today's value those calculations will be wrong.

If the decision means that a future present value is to be taken at a time when a unit of property is replaced, how in the world will we be able to establish correctly at this present date what that value will be in ten years from now?

For brief consideration, let us apply different yardsticks to a few simple examples. As I said before, if we use today's present value as a basis for accruing depreciation with the knowledge that this value will not hold for the future years, and if the theory of this decision is to be taken to mean that depreciation is to be accrued on the basis

of the value of the property at the time the unit is replaced at some future period, we will assume an impossible position by saying that we know that a particular meter will be worth $8.00 in 1940, at which time it is to be replaced, and we proceed to accrue depreciation on the basis of that $8.00 future present value. In 1940 the meter is to be retired from service and replaced with a new $8.00 meter, but when we arrive at 1940 where we wish to retire that meter from the Fixed Capital Account, we find that the original cost of the meter was $10.00 and that we have only collected $8.00 from the rate payers to be used for replacement purposes. Then we are immediately confronted with the problem as to where the other $2.00 is coming from and we find that it becomes an absolute loss to the stockholders. In other words, the original cost of the meter was $10.00 which the stockholders paid and they now find that the $10.00 meter has been retired from service and that they are reimbursed only to the extent of $8.00. When you multiply this simple illustration many times over it amounts to a considerable sum and I wonder what the stockholders will have to say?

Let us take another example. Suppose the stockholders paid $8.00 for a meter in 1929 and we are going to apply the principle of this decision in which we are to find from some magical source that the cost to replace that meter in 1940 will be $10.00. Then again we begin to accrue our depreciation on the basis of the future present value at the time the unit is to be retired, which will be $10.00, and in 1940 the meter is retired, and we find that we have collected $10.00 from the rate payer with which to replace a $8.00 meter. Thus we retire the $8.00 meter from the Fixed Capital Account and the balance of $2.00 becomes a distinct gain to the company, either through an appraisal of the property or a charge to Fixed Capital, and the rate payer is called upon to pay a return on the $2.00 which he contributed.

Now in order to get this thing mixed up a little more, let's not try to fix a future present value, but use today's present value.

The original cost of the meter is $8.00 but the present value is $10.00, and we accrue depreciation on $10.00, and in fifteen years from now the meter is replaced, but we find that prices have changed downward again and it costs only $8.00 to replace this meter. Therefore, we have $10.00 contributed by the rate payers to replace a $8.00 meter. Will the Regulatory Commissions permit the stockholders to keep the extra $2.00 which we have collected or will it have to be returned to the rate payers, and if so, just how will that be done?

Again, let's take the entire public utility situation into consideration for a few moments. The peak of prices was reached in 1919 and 1920 and they have been comparatively high since that time but with downward trend. There has been very extensive construction work done in the last ten years and if this rule of computing depreciation on today's present value is followed, it will no doubt result in using a depreciation basis substantially less than the original cost of property constructed in recent years, with the result that the stockholders will not be reimbursed in the full amount of the original dollars invested, which dollars have been consumed in the rendition of service.

Some of you may be inclined to agree with the theory of the Court, that, if the present value is to be used for return purposes, likewise so should the depreciation base, but in my opinion these are two entirely separate and distinct questions. Briefly, the rate of return is fixed on today's present value upon the theory that the earnings of the stockholders should keep pace with the purchasing power of a dollar as is true in practically all other lines of endeavor.

The fundamental theory of depreciation as quoted by some is to keep the property in as nearly one hundred percent condition as possible, but in so doing the original dollar invested must be protected.

Summed up briefly, the situation is this. If the old-fashioned method of accruing depreciation on the basis of the original cost of the property is followed, the stockholders' original investment is protected and the rate payer simply returns that money to him.

If this Court decision is followed, I can see some interesting situations ahead of us, for it will be practically impossible to accrue the correct amount of depreciation to replace a unit in the future at the then present value, because the amount will be either too much or too little. If it is too much, I feel sure that the Regulatory Commissions and the patrons are going to object, and if it is too small, I feel equally sure the stockholders will be heard from.

It is my humble opinion that, from the standpoint of correctly keeping the accounting records, the safest and soundest method is to continue to accrue depreciation upon the basis of the definite and ascertainable cost, rather than upon the indefinite theory of a judgment figure which must be furnished from time to time by the Engineering Department and which of necessity must be ever changing in accordance with the constant shifting in commodity price levels.

All of the foregoing remarks are offered as a stimulant to the argument that the accounting records should not be changed in an effort to comply with this Court decision. However, I wish it to be distinctly understood that all utilities are now entitled to present properly prepared exhibits in rate case controversies which will support a claim for depreciation on present values, if they care to do so, as they will be wholly within their rights under this Maryland decision.

SOCIETY AFFAIRS

THE CENTRAL STATES SECTION

The thirty-second annual convention of the Central States Section was held in Youngstown, Ohio, September 25 and 26, 1930, at the Hotel Ohio and was everything that could be desired. There were 118 delegates present, an increase of 10 percent over last year's gathering. In addition there were nineteen ladies in the group. The program was excellent and satisfactory in every way.

The open forum particularly held the interest of the delegates long beyond the allotted time.

New rules and regulations were adopted at the meeting, subject to the approval of the Parent Association. Mr. George H. Fenkell, President of the American Water Works Association, attended the Convention and acted as Chairman during part of the sessions. Mr. W. H. Dittoe, Chief Engineer of the Mahoning Valley Sanitary District, Youngstown, Ohio was elected President; B. J. Lechner, Secretary-Treasurer, Commissioners of Water Works, Erie, Pa., Secretary and George H. Keefer, Pittsburgh Representative of the Rensselaer Valve Company, was elected a member of the Board.

The program was as follows:

THURSDAY, SEPTEMBER 25

Morning Session

9:00 a.m. Registration.

10:00 a.m. Convention called to order by E. E. Bankson, President Central States Section.

10:00 a.m. Address of Welcome, Hugh W. Grant, President, Chamber of Commerce, Youngstown, Ohio.

10:15 a.m. Certain Phases of Accounting for Water Utilities—C. P. Maloney, Public Accountant, Associated with The J. N. Chester Engineers, Pittsburgh, Pa.

11:00 a.m. Recent Developments in the Purification of the Cleveland Water Supply at the Baldwin Filtration Plant—W. C. Lawrence, Superintendent of Filtration, Cleveland, Ohio.

11:45 a.m. Announcements.

Afternoon Session

2:00 p.m. Valve Location Records for Use on Maintenance of Valves and Services—Albert S. Hibbs, Superintendent, Department of Water, Cincinnati, Ohio.

3:30 p.m. Tentative Draft of Standard Specifications for Steel Standpipes and Elevated Tanks—L. R. Howson, Consulting Engineer, Chicago, Ill., Chairman Sub-Committee on Steel Standpipes and Elevated Tanks, A. W. W. A.

4:30 p.m.—Election of Officers.
Selection of place for 1931 Meeting.

Evening

7:00 p.m. Dinner at Hotel Ohio.
Address by Hon. Joseph L. Heffernan, Mayor of the City of Youngstown.

FRIDAY, SEPTEMBER 26

Morning Session

9:00 a.m. to 10:30 a.m. Open Forum Discussion of Practical Questions of Water Works Operation and Maintenance.
Meeting in charge of D. C. Grobbel, Acting Secretary, Board of Water Commissioners, Detroit, Mich.
Partial List of Questions:

1. What method should be used to secure payment for water used in construction work?
2. Should water department furnish free water for publicly owned swimming pools?
3. How frequently should meters be read and bill rendered?
4. Should meters be owned by the water department or by the consumer?
5. What are the respective advantages of lead and non-metallic compounds for joints in cast iron pipe?
6. What method should be used for financing extensions? improvements?

Those in attendance are invited to introduce other topics.

10:30 a.m. to 12:00 noon. Open Forum Discussion of Practical Questions of Water Purification.
Meeting in charge of Chester F. Drake, Division Superintendent, Aspinwall Filtration Plant, Pittsburgh, Pa.
Partial list of topics:

1. Purification Data and Forms. What are essential and how recorded?
2. What special provisions are necessary for the disposal of sludge from water softening plants?
3. Filtration plant capacity. How should it be measured?
4. Effect of manganese deposits on filter efficiency.
5. What is the meaning and significance of pH value?
6. What properties of water cause it to be corrosive?

Those in attendance are invited to introduce other topics.

Afternoon

1:30 p.m. Inspection Trip. Meander Creek Reservoir Development, Warren Water Purification Plant, Square Creek Reservoir Development.
Golf at the Mahoning Valley Country Club.

ENTERTAINMENT FOR LADIES

Thursday, September 25

2:00 p.m. B. F. Keith Palace Theatre.
7:00 p.m. Dinner at Hotel Ohio.

Friday, September 26

10:00 a.m. Reading of Palms of the Ladies. Mr. C. P. Maloney who has had sixteen years' practice (not professionally) as a palmist will tell good news to the ladies (individually), on the Mezzanine floor, Hotel Ohio.
1:00 p.m. Bridge Luncheon. Tea Room—McKelvey Department Store.

B. J. LECHNER,
Secretary-Treasurer.

THE NORTH CAROLINA SECTION

The tenth annual convention of the North Carolina Section, American Water Works Association and the eighth annual meeting of the North Carolina Sewage Works Association were held jointly at the Skyland Hotel, Hendersonville, on October 13, 14 and 15, 1930. Sixteen states of the south, east and middle west, and one foreign country were represented at the meeting. The registration reached 236, of whom 131 were city officials, superintendents, plant operators, engineers and public health officials actively engaged in the planning, design, construction, operation and financing of water and sewage works; 61 were commercial representatives of manufacturers and dealers in water works and sewerage equipment and supplies; 9 were special representatives of professional journals and the press; and 35 were ladies and other visitors. The exhibits of about thirty firms were attractively arranged in the lobby and adjoining rooms of the hotel, and, as usual, constituted one of the most attractive features of the convention.

President C. W. Smedberg of Greensboro and Vice President T. C. Patterson of Mount Holly presided at the sessions of both organizations.

The opening morning of the convention was devoted to registra-

tion, a general get-together for conversation, renewal of old acquaintances and the establishment of new ones, and for the inspection of manufacturers' exhibits.

The afternoon session of the first day was opened by a comprehensive paper on "The Protection of Mountain Watersheds" by Stanley H. Wright, City Engineer of Asheville, N. C., which was beautifully illustrated by lantern slides and moving pictures furnished by the National Forest Service. A round-table discussion of general water works topics followed, which was led by J. O. Craig, Superintendent of Water Works of Salisbury, N. C. Among the many subjects considered were: Unaccounted for Water, Sale of Surplus Water, Contractors' Use of Fire Hydrants, Public Use of Reservoirs, Metering of Free Water Services, Damage to Property Due to Leaks in Streets, Efficient Meter Reading, Who Owns the Service Pipe?, Repairs to Service Pipes, Enforcement of Local Water Rules and Regulations, Suitable Types of Service Pipe, Efficiency of Pumps, Checking Inactive Services, Separate Service for Each House, and Deposits for Automobile Service and Filling Stations. The session was concluded by an interesting and scenic automobile trip to the reservoir and distribution works of the Hendersonville water supply, located in Laurel Park on the Mountain side above the city, and to the Fleetwood Hotel site among the clouds on the top of Jump-Off Mountain.

On Monday evening the City of Hendersonville was host to the convention at a dinner at Hotel Skyland, which was enjoyed by more than 200 guests. Hon. W. M. Sherard, Mayor, welcomed the visitors in a very pleasing address, and commended them for the splendid professional service which they are rendering the municipalities and industries of the State. President Smedberg responded for the Association, thanking the city officials for their kind hospitality and tireless effort which had made the meeting so pleasant and successful an occasion. Mr. J. H. Lampley, Manager of the Board of Water Commissioners, presented a paper giving the historical background and description of the development of the splendid and abundant mountain water supply of the City of Hendersonville. Following the dinner, the annual Association Ball was enjoyed by a hundred couples.

On Tuesday morning Geo. F. Catlett of the North Carolina State Board of Health opened the program with a paper "Sewage Flows," in which he showed graphically the hourly, daily and seasonal varia-

tions in sewage flows for a large number of North Carolina municipalities in which accurate and longtime records have been obtained by gaging. Characteristic curves for different types of communities have been established, and the effects of industrial waste discharge and infiltration demonstrated. Mr. Michael J. Blew, Research Engineer of the Dept. of Public Works, Philadelphia, Pa., followed with a paper on "Chemical Contamination of Public Water Supplies and Its Effect upon Health," in which he advanced the suggestion that dissolved materials resulting from the discharge of sewage and industrial wastes into streams used as sources of water supply may constitute a serious menace to health, that the physiological effects of such dissolved matter should be investigated and that chemical, as well as bacteriological standards, should be established for determining the safety of water supplies for domestic consumption. A very interesting paper entitled "The Separation, Treatment and Disposal of Sewage Solids" was given by John R. Downes, Supervising Engineer of the Plainfield, N. J., Sewage Treatment Works. Mr. Chas. C. Hommon, Sanitary Engineer, Dept. of Public Service, Canton, Ohio, read a paper on "Utilization of Imhoff Tank Sludge for Farm Fertilizer," describing the successful method employed at his plant of pumping digested sludge directly from the tanks to farm land in the vicinity of the treatment works. The session was concluded by a live round table discussion, led by E. C. McConnell, Superintendent of Plants, Charlotte, N. C., on general sewage treatment topics. Among the subjects discussed were: Advantages of agitation of sludge during digestion, the relative importance of drainage and evaporation in sludge drying, proper concentrations and depths of sludge to be drawn on drying beds, the processing of digested and dried sludge for use as commercial fertilizer, and forecasts as to the ultimate type of sewage treatment.

On Tuesday afternoon, R. W. Luther, Superintendent of Filtration, Hertford, N. C., read a paper on "Conquering the Perquimans River Water," in which he described the rehabilitation of the water treatment plant at Hertford and the very unusual methods employed in the treatment of a very highly colored water containing at most times objectionable tastes and odors and a high content of organic acids. Mr. J. W. Kellogg, Chief Chemist and Bacteriologist of the State Laboratory of Hygiene, Raleigh, N. C., in a paper "Residual Alum in North Carolina Filtered Waters" recapitulated the results of five years' study on residual alum in the monthly samples of water sub-

mitted to the Laboratory, correlated these results with the deviation from the optimum pH values for coagulation of the various supplies, explained the application and value of the residual alum test as a check on the efficiency of coagulation, and outlined the technique for making this determination. A symposium on "The Control of Water Fleas and Midge Fly Larvae in Water Reservoirs" followed, which was led by E. M. Johnson, Superintendent of Plants, Monroe, N. C., who gave his experience with the use of chlorine in controlling cyclops. Others contributed to the discussion with experiences in the control of various forms of crustacea and larvae with chlorine and copper sulphate. In the round table discussion the following subjects were treated: Experiences with fish killing, due to toxic poisoning by industrial wastes, depletion of oxygen in reservoirs, abnormal temperature conditions, and suffocation by physical clogging of gill passages.

The tenth annual Association banquet was held on Tuesday evening, which was attended by two hundred. Entertainment in the form of singing, dancing and instrumental music was furnished by local talent, which in quality was worthy of Broadway. Mr. Stanley H. Wright, City Engineer of Asheville, presided as toastmaster in his best English manner. Mr. E. G. McConnell gave an interesting history of the ten years development of the North Carolina Section, pictured its growth from 9 members at the time of its organization to 130 at present, and related the part the organization had played in the marvelous improvement of the physical plants and operation of the water supply and sewage disposal works of the State and the reduction of the general typhoid death rate from 36 to 5.2 during the ten-year period. Mr. McKean Maffitt of Wilmington presented the Maffitt Membership Cup to R. D. Beam of the State Board of Health for having secured the greatest number of new members for the Section during the past year. Mr. Beekman C. Little, Secretary of the American Water Works Association, present for his fifth consecutive meeting of the Section, brought greetings and good wishes from the parent organization, and expressed his feeling that the North Carolina group was the livest of all the local sections of the Association.

On Wednesday morning the program was opened by Roy S. Lanphear, Supervising Chemist of the Worcester, Mass., Sewage Treatment Works, with a paper "The Treatment of Sewage Containing Industrial Wastes," giving his experience in dealing with the

complicated problems at Worcester. Mr. R. V. Toms, Superintendent Water and Sewer Departments, Shelby, N. C., described the methods which he employed in starting a new Imhoff tank in operation. "Activated Sludge Digestion at Salem, Ohio" was the subject of a paper by Anthony J. Fischer of the Dorr Co., New York, in which he described his extensive research studies on the digestion of activated sludge. Dr. F. W. Mohlman, Chief Chemist of the Sanitary District of Chicago, described the various sewage treatment plants of the Sanitary District and illustrated his talk with numerous lantern slides. Mr. Geo. F. Catlett of the North Carolina State Board of Health gave the final paper of the meeting on "The Industrial Waste Problem in North Carolina," in which he discussed the stream pollution problems with which the industries are faced, the extensive studies and investigations which have already been made by the industries and State agencies, and the program for the future.

At the joint business meeting of the two associations Greensboro was selected as the next convention city, and the dates fixed as November 2, 3 and 4, 1931. The officers elected for the coming year are as follows:

President: A. S. Lyon, Rocky Mount, N. C.

Vice-President: Geo. S. Moore, Albemarle, N. C.

Secretary-Treasurer: H. G. Baity, Chapel Hill, N. C.

Editor: E. G. McConnell, Charlotte, N. C.

Representative on Board of Directors, American Water Works Association: W. E. Vest, Charlotte, N. C.

Representatives on Board of Control, Federation of Sewage Works Associations: H. E. Miller, Raleigh, N. C.; W. M. Piatt, Durham, N. C.

Chairman of Nominating Committee: J. O. Craig, Salisbury, N. C.

The Section authorized the appointment of a special committee to represent it before the 1931 General Assembly in support of ample appropriation for the very necessary work of stream gaging. Another special legislative committee was authorized to cooperate with a similar committee from the North Carolina Society of Engineers in support of a State appropriation of $28,000 to supplement $83,000 of Federal funds to complete the base mapping of the State by the U. S. Coast and Geodetic Survey. At present only 36 percent of the State is covered by existing topographic maps, and no work has been done in the last 30 years toward improving this situation.

Resolutions were adopted expressing the deep sorrow of the Section

at the passing of Col. J. L. Ludlow, first president of the organization, Mr. Claude W. Absher, loyal and active member, and Dr. Chas. O. H. Laughinghouse, State Health Officer and staunch friend of the Section. Resolutions were also passed thanking the city officials and good people of Hendersonville for their splendid hospitality and entertainment afforded to this convention, the Skyland Hotel for their courteous and efficient service, and the press representatives who have transmitted to the people of the State and Nation an interpretation of the very vital enterprises in which these associations are engaged.

H. G. BAITY,
Secretary.

ABSTRACTS OF WATER WORKS LITERATURE[1]

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Tests Show Color Affects Surface Temperature of Concrete Dam. F. J. MILLS. Eng. News-Rec., 103: 579, 1929. Tests were made at Florence Lake dam to determine whether flaking of the black waterproofing compound applied during construction was due to temperature variations. A recording thermometer was placed in a shallow channel cut in the face of one of the arches, grouted over, and covered with the waterproofing compound; a second thermometer was similarly placed in an adjacent arch and the surface of the dam for an area of 10 feet square around the thermometer was given a coat of aluminum paint; and a third thermometer measured the atmospheric temperature. Curves are given showing the records obtained on 2 characteristic days. In one instance with a maximum air temperature of 50°F., the temperature of the Al-coated section was about 68° and of the black-coated section, 107°. The study is being continued.—*R. E. Thompson (Courtesy Chem. Abst.).*

Exceptionally Dry Concrete Used on Two Large Dams. Eng. News-Rec., 103: 640–2, October 24, 1929. Using electric vibrators to compact concrete mixed so dry that it stands in a stiff heap when dumped from the buckets is the revolutionary practice in concrete placing being employed by the Aluminum Co. of America in the construction of two of its widely separated hydroelectric projects, one near Kenogami, Quebec, and the other at Calderwood, Tennessee. The concrete is designed for a strength of 3000 pounds per square inch, at 28 days. Details of the concreting process are given.—*R. E. Thompson.*

Small Arch Dam Design Governed by Concrete Economy Need. JAMES GIRAND, Jr. Eng. News-Rec., 103: 569–70, October 10, 1929. Limited funds available for increasing the water supply of Safford, Arizona, necessitated rigid economy in construction of a variable radius arch dam, containing 970 cubic yards of concrete, for developing a 153-acre-foot reservoir site. Brief details are given of the method of concrete control. Copper water stops, 12 inches wide, were placed at all construction joints.—*R. E. Thompson.*

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[1] Vacancies on the abstracting staff occur from time to time. Member desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

Notes on German Water Works from a Far-Eastern Viewpoint. H. STRINGER. Eng. News-Rec., 103: 580–3, 1929. Shanghai, China, derives its water supply from the Huangpu River, which is very turbid and highly polluted. The per capita consumption is 29 gallons per day and the population, 900,000. This paper consists chiefly of a description of water works visited in Germany in search of information which would facilitate treatment of this troublesome supply. The water works of Köln and Hamburg and two of the 13 plants supplying greater Berlin are described. Water supplies in Germany are drawn chiefly from ground water sources, the sub-surface water level in the whole northern section being only 23–26 ft. below the ground. This water is raised by the Hof system, which consists of a large horizontal main at a depth of about 50 feet, into which are tapped vertical Cu collecting pipes about 6 inches in diameter penetrating to the selected sterile water bearing strata. The latter pipes, which are placed in lined auger boreholes, are spaced 33 to 66 feet apart and are slotted for a length of at least 10 feet. The collecting main, housed in a tunnel, delivers the water to a sealed well, from which it is pumped. The Köln system is of this type and consists of a horizontal collecting main about 43 feet below ground, 43 inches in diameter and 6560 feet in length, and two hundred 5.9-inch supply pipes running into a sand bed at a depth of 92 feet below ground.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Storage of Water at Ground Level. J. A. FULKMAN. Eng. News-Rec., 103: 508, September 26, 1929. The Chicago water department sells water to some 30 adjoining municipalities, stipulating however that the water must be drawn at the average rate of use. To comply with this regulation a number of the municipalities have constructed ground level reservoirs, to be filled during the night or during periods of low consumption. Booster pumps deliver the water from the reservoirs to the distribution systems when the consumption is above average. The writer believes that elevated storage would be as advantageous, and more economical, eliminating energy losses.—*R. E. Thompson.*

A Sensitive Electrical Device for Determining Surface Elevations. H. A. DIBBELL. Eng. News-Rec., 103: 584–5, 1929. An electrical device for determining the elevation of water surfaces, as in tunnel shafts, developed by the Board of Water Supply, New York City, is described. In still water, readings seldom varied more than 0.001 foot; in water flowing at rates of 4.5 feet per second, the average of different sets of 10 readings should not differ by more than 0.03 foot. In a comparison of 60 sets of observations where maximum surge was 2 feet, the greatest difference between the averages of different sets of 20 readings each was 0.07 foot.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Gas-Main Accidents in Europe Due Chiefly to Cold. CARL HANNS POLLOG. Eng. News-Rec., 130: 496, September 26, 1929. If minor occurrences were included, the number of main accidents recorded last winter would probably have been as great as 500. The causes were probably deterioration of material, increased traffic, and the exceptionally low temperatures which in most regions established records. The peak of the curve of accidents exactly coincides with the period of severest frost. The mains were not designed for these tempera-

tures and the solidly frozen ground transmitted vibrations due to traffic to greater depths.—*R. E. Thompson.*

Construction of Concrete Dam Complicated by Proximity of Old Dam. Cont. Rec. and Eng. Rev., 43: 1224–5, October 9, 1929. Difficulty was encountered in construction of new concrete dam on the Otonabee River with overall length of 306 feet, due to the fact that the old and new dams were only 7 feet apart, the river bed dropping 3 feet in this distance. For dewatering, a combination of the coffer and apron types of dam was selected, the former being built between the noses of the new dam and the aprons facing these noses. Brief details given.—*R. E. Thompson.*

Volumetric Meter for Irrigation and Industrial Uses. Eng. News-Rec., 103: 507, September 26, 1929. Brief illustrated description of meter invented by C. MILTON ANDERSON, Salt Lake City, Utah.—*R. E. Thompson.*

Standing Wave Flumes Again Compared with Venturi Meters. C. C. INGLIS. Eng. News-Rec., 103: 701, 1929. Further discussion (cf. C. A., 23: 4598, etc.). —*R. E. Thompson (Courtesy Chem. Abst.).*

Ogden Typhoid Outbreak Attributed to Public Water Supply. Eng. News-Rec., 103: 457, September 19, 1929. Reports of State Health Commissioner (T. B. BEATTY), United States Public Health Service (A. L. DOPMEYER), and of bacteriologists employed by the city health department of Ogden re typhoid outbreak in June and July. There were 19 cases and 5 deaths. Main source of city water supply is group of artesian wells located approximately 10 miles from city, the quality of which has never been questioned, supplemented during the summer from the flow of Wheeler Creek. The latter flows through a canyon frequented by hikers and campers and, on the basis of bacteriological findings, discontinuance of its use, or chlorination, had been urged by the state health commissioner, the Utah State Board of Health having no legal authority to prohibit the use of a polluted supply. Prior to outbreak this auxiliary supply had been mixed with artesian water without treatment in the ratio of 1 to 5 volumes. On June 10 and 11 and June 16 and 17 rains occurred on the watershed and, after period equal to the usual incubation period for the disease, two distinct outbreaks of typhoid occurred. City's bacteriologist suggested contaminated food as probable source of outbreak, this theory accounting for the limited number of cases, the tracing of all cases to common source of infection at a certain lunch counter, and the high mortality rate, which is uncommon in water-borne outbreaks. The health commissioner believes contamination of the water supply to be the only reasonable source of outbreak and the United States Public Health Service report also considers the water supply as a very reasonable source of infection.—*R. E. Thompson.*

Automatic Roof Weirs Used for Reservoir Control on Guadalupe River. E. L. CHANDLER. Eng. News-Rec., 103: 685–8, October 31, 1929. Illustrated description of spillway structures and automatic floodgates used on the 3 hydro-electric developments of the Texas Power Corporation on the Guadalupe River.—*R. E. Thompson.*

Parkersburg Removes CO_2 from New Well Water Supply. MYRON G. MANSFIELD. Eng. News-Rec., 103: 727–8, 1929. A description of the new 6-million-gallon per day water supply system of Parkersburg, W. Va., which consists of 12 gravel wall wells along the east bank of the Ohio River about 300 feet apart, aërators of the Sacramento spray nozzle type, mechanical mixing chamber, and clear well. No chemicals are at present employed. The CO_2 content of the treated water is 6–8 p.p.m., and the Fe content, 0.2 to 0.3 p.p.m.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Providing for a 2418-Foot Head on the Big Creek 2-A Penstock. H. L. DOOLITTLE. Eng. News-Rec., 103: 482–5, September 26, 1929. Features of the design and construction of penstock of Southern California Edison Company's 2-A plant at Big Creek, which was designed for static head of 2418 feet and maximum capacity of 540 second-feet. Single line was made possible by the use of seamless forged steel pipe for that portion of the line having head in excess of 1642 feet and by the fact that the plant would be inoperative part of the year, permitting inspection and repair. The penstock consists of 1858 feet of quadruple-riveted pipe varying from 108 to 84 inches in diameter and from $\frac{8}{16}$ to $1\frac{5}{16}$ inches in thickness; 3042 feet of banded forge-welded pipe varying from 84 to 66 inches in diameter and with thickness of $1\frac{1}{4}$ to $2\frac{1}{4}$ inches; and 1764 feet of seamless forged pipe, practically all 66 inches in diameter, with thickness varying from $2\frac{1}{2}$ to 3 inches. Details of the banded and seamless forged steel pipes are included, and the manufacture of the latter is outlined. The supporting piers are of concrete with the exception of a few, which are of steel. Many tests were made to determine the most suitable material to insert between the piers and the pipe to reduce friction, $\frac{1}{16}$-inch asbestos sheeting impregnated with graphite being selected. Two sheets are used at each bearing point, one being cemented to the pipe with red lead and the other cemented to the top of the concrete pier. Y's were provided at lower end of the line to divide it into 4 branches. A 102-inch motor-operated butterfly valve was installed at the top of the penstock, arranged for remote control, which will close automatically, actuated by mechanism from Venturi tube, when velocity increases to approximately 100 percent above normal. Immediately below the valve, 4 pairs of 10-inch air valves are provided for admitting air when valve closes.—*R. E. Thompson.*

Earth Dam with Spillway Channel Through Embankment. Eng. News-Rec., 103: 725–7, November 7, 1929. A description of an earth dam completed in 1928 for the water supply of Mitchell, S. D., at a cost of $131,951. Reservoir formed is about 4 miles long and $\frac{1}{2}$ mile wide, with maximum depth of 38 feet and capacity of 2,800 million gallons. The dam, about $\frac{1}{4}$ mile north of the city, is $\frac{1}{4}$ mile long and 40 feet high. The top is 30 feet wide and is to be covered with concrete roadway. Concrete paving 6 inches thick, for wave protection, is laid on the upstream slope from the top to about 3 feet below an assumed low-water level. A trench was cut down to solid clay under the upstream slope across the valley, in which was driven a continuous line of steel sheetpiling to guard against seepage due to sand pockets and to cut off springs which had been encountered. The spillway is part of the dam, the crest being 10 feet below the

top of the dam and the channel being protected by a concrete slab floor 6 inches thick. Data on erosion of the dam during filling and on settlement of the spillway are included, together with criticisms of design which were made before the work was started.—*R. E. Thompson.*

Lining Canal with Concrete on the Yakima Project. Eng. News-Rec., 103: 722–4, November 7, 1929. Canal lining and drainage problems on Yakima irrigation project of United States Bureau of Reclamation are described and illustrated. About half the 26-mile length of main canal is being lined with concrete, in general 3 inches thick, first to reduce the canal section required and second to prevent excessive seepage losses and give security on steep side hills. A major problem was the drainage of the lined sections to prevent upheaval of the lining by ground water pressure when canal is empty. Despite the utmost care, ground water did develop pressure under lining in a few places, causing serious cracking, one 28-foot section being blown out.—*R. E. Thompson.*

Rockfill Dam on Virgin River, Nevada, Washed Out During Construction. Eng. News-Rec., 103: 526, October 3, 1929. Brief details given of failure during construction of rockfill dam in narrow canyon of Virgin River. Proposed height was 120 feet.—*R. E. Thompson.*

Gravelbourg, Saskatchewan, Improves Water Service. M. GRADY. Cont. Rec. and Eng. Rev., 43: 1327, November 13, 1929. The water supply of Gravelbourg, Sask., is derived from three 150-foot wells. The system was recently improved by the construction of an elevated steel tank of 62,500 gallons capacity, the bottom of which is 120 feet above the ground. The water contains 20.07 grains per gallon of permanent hardness and has a total solid content of 123 grains per gallon. Chlorination is employed.—*R. E. Thompson.*

Annual Cost of Metered Water in 21 Wisconsin Cities. Eng. News-Rec., 103: 655, October 24, 1929. The annual cost of metered water in 21 Wisconsin cities of over 10,000 population in 1920 is shown in table compiled by L. A. SMITH. Fourteen of the cities make a service charge to domestic consumers, ranging from 50¢ to $14.40 per year. The annual industrial charge in 6 cities varies from 50¢ to $259.20. The annual domestic water bill for consumption of 10,000 cubic feet would range from $9 to $40 per year. For industrial uses, 1 million cubic feet per year would cost from $443.20 to $1714.20.—*R. E. Thompson.*

Heavy Rainfall and Hail in Central Massachusetts. HARRISON P. EDDY, Jr. Eng. News-Rec., 103: 628, October 17, 1929. Brief data on storm of September 29, 1929.—*R. E. Thompson.*

Bœuf Floodway for Mississippi Flood Control. Eng. News-Rec., 103: 379–82, September 5, 1929. In the Mississippi River flood control plan, protection of the middle river, from the Arkansas River to the Red River, is provided by the Bœuf basin floodway, which will divert from the main river the flow in excess of 1,950,000 second-feet, the amount that can be carried between the raised levees of this stretch of the Mississippi. Entrance to the floodway

will be by a section ("fuseplug") of the present main river levee south of the mouth of the Arkansas River and about 30 miles long. The floodway design is described and illustrated.—*R. E. Thompson.*

Atchafalaya Floodway for Mississippi Flood Control. W. W. DE BERARD. Eng. News-Rec., 103: 492–5, September 26, 1929. Details are given of the floodway and its function.—*R. E. Thompson.*

Engineer District Organization for Mississippi Flood Protection. W. W. DE BERARD. Eng. News-Rec., 103: 571–4, October 10, 1929. Description of district organizations which are building the flood control works in the Mississippi Valley.—*R. E. Thompson.*

Stabilization Methods Used on the Indus Recommended for the Mississippi. P. CLAXTON. Eng. News-Rec., 103: 619–21, October 17, 1929. The formation of still-water pockets, as used to control the Indus River, is believed applicable to the Mississippi problem. Possibility of application to Plum Point Beach section discussed.—*R. E. Thompson.*

The Cairo Flood Problem. C. E. HILLMAN. Eng. News-Rec., 103: 702, October 31, 1929. A criticism of the wisdom of the measures being adopted for protection of the city of Cairo from Mississippi floods.—*R. E. Thompson.*

Stream Flow Measured by Simple Method. G. GOODWIN. Eng. News-Rec., 103: 661, October 24, 1929. Brief description of method of measurement by timing floats fastened to 100 feet of fishing cord mounted on a simple reel. One man can obtain better results with this method than 2 men with usual method.—*R. E. Thompson.*

Divers Place Pipe in 60 Feet of Water on Seattle Sewer Job. Eng. News-Rec., 103: 782–3, November 14, 1929. Brief description of laying of a 700-foot length of cast iron outfall sewer pipe, 4 feet in diameter, in the east waterway at Seattle in water depths ranging up to 60 feet. Owing to the soft bottom, the pipe had to be supported on piles, which were driven in a trench. The pipe was lowered into the water in 36-foot lengths consisting of three 12-foot sections that had been fastened together on shore. The weight of each 36-foot length was about 13 tons. All subaqueous joints were calked with lead wool by divers.—*R. E. Thompson.*

Concrete Plug Drilled and Blasted Under 180-Foot Head of Water. Eng. News-Rec., 103: 781–2, November 14, 1929. Brief description of removal of concrete plug 6 feet thick to open penstock in Don Pedro dam of Turlock Irrigation District on Tolumne River in California. After other methods had failed the work had to be carried out from the penstock toward the upstream face that was sustaining a 180-foot head.—*R. E. Thompson.*

Peterborough's Filtration Plant has Electrically Illuminated Fountain. R. L. DOBBIN, Cont. Rec. and Eng. Rev., 43: 1233–4, October 16, 1929. Brief

description of new illuminated fountain at the filtration plant park in Peterborough. There is a central jet of water which attains a height of 35 feet, surrounded by a 4-foot ring of fine spray 10 feet high. Illumination is effected by 7 projectors of the submerged type, each containing a 1000-watt lamp, the central one, immediately under the nozzle, containing a clear lens and the six others, arranged on the points of a hexagon under the fine spray, are red, green, and amber, 2 of each color.—*R. E. Thompson.*

West Kootenay Completes No. 3 Plant at South Slocan, B. C. Cont. Rec. and Eng. Rev., 43: 1242–9, October 16, 1929. Illustrated details are given of the construction of the 56,000-kw. plant of the West Kootenay Power and Light Co., on the Kootenay River, which includes several dams, constructed chiefly of concrete.—*R. E. Thompson.*

Building High-Head Siphons on the Yakima Project. Eng. News-Rec., 103: 763–5, November 14, 1929. The main canal of the Kittitas division of the Yakima project required 11 inverted siphons in its 26-mile length, and, including those built in the two branch canals as part of the construction program being carried out by the United States Bureau of Reclamation, 25 siphons in all are being constructed. A notable feature is the 925 second-foot pressure tunnel which is to convey water beneath the Yakima River under a head of 523 feet. Details of construction are given. The siphons for the most part are circular in section and, in the main canal, about 12 feet in inside diameter, cast as monolithic reinforced concrete. Where the head was excessive, or under certain foundation conditions, steel pipe was substituted for concrete. By experiment it was found that addition of a maximum of 3 percent of diatomaceous silica to the leaner concretes resulted in a marked improvement in workability and impermeability and lessened the tendency to segregation. Additions to richer mixes did not prove beneficial.—*R. E. Thompson.*

Long Period Settlement Records of Two Earth Dams. J. Albert Holmes. Eng. News-Rec., 103: 769–772, November 14, 1929. Records of settlement of Somerset dam and of the Davis Bridge dam on the Deerfield River are shown graphically and in tabular form. The former, 105 feet high, was completed and placed in service in 1913 and the latter, 216 feet high, in 1923. The dams are part of the system of the New England Power Co.—*R. E. Thompson.*

Cost of Jacking Culvert Through Fill Compared with Open Cut Method. W. Mack Angas. Eng. News-Rec., 103: 663–4, October 24, 1929. A 48-inch corrugated iron culvert 126 feet long was jacked through a 34-foot fill carrying a concrete highway at the Naval Fule Depot, San Diego, at a cost of but one-third of that estimated for open cut work.—*R. E. Thompson.*

Largest Hydro-Electric Plant of the Orient Being Built in Chosen (Korea). Taneyuki Matsumura. Eng. News-Rec., 103: 678–82, October 31, 1929. A detailed description of a hydro-electric plant being built in Chosen (Korea). The Fusenko River is being dammed at a gorge by a 250-foot dam, forming a reservoir of about 25 billion cubic foot capacity. By means of 3 steps of con-

duits and power stations, 260,000 hp. can be developed. The dam is a concrete gravity section of the overflow type, 250 feet high, 1308 feet long, and 184.24 feet wide at the base of the maximum section, excluding the apron. The waterway consists of a horseshoe-shaped, concrete-lined tunnel, 13 feet 3 inches by 12 feet 3 inches, which will be under a pressure head of 150 to 200 feet. Reinforcing steel is being used where the rock is weak, or where there are faults in the stratum. After the lining is finished, the space behind it throughout the length of the tunnel (16.65 miles) will be filled with grout mortar under a pressure of 70 pounds. The penstock is 9730 feet long, of which the upper 550 feet consists of pipe $\frac{7}{16}$-inch thick with inside diameter of 10 feet 4 inches. The lower section consists of 4 pipe lines of 64-inch internal diameter at the upper end and 45-inch near the waterwheel. The upper section was constructed in a 15-foot tunnel, the annular space outside the pipe being filled with concrete. —*R. E. Thompson.*

Serious Defects in Foundation Rock Stop Work on San Gabriel Dam Project. Eng. News-Rec., **13**: 699–701, October 31, 1929. Essential parts are given of the report of the board of engineers and geologists appointed by the Los Angeles Flood Control District to study the foundation conditions at the site of the San Gabriel dam following the rock slide of about 20,000 cubic yards which occurred on September 16. The board reports that the foundation conditions are so serious that "a safe dam of the proposed height cannot be built on this site."—*R. E. Thompson.*

Method of Placement an Important Factor in Checking Percolation through Dams. W. G. CHACE. Eng. News-Rec., **103**: 664–6, 1929. A discussion of percolation through concrete dams (cf. BOWERS, C. A., **23**: 4984) in which the method of placement is stressed. It is shown that application of grout to construction joints in the concrete mass before starting a new pour results in a distinct plane of separation. Effective wetting of the set concrete after the laitance and an inch or two of porous concrete beneath the laitance has been removed will permit immediate placing of regular concrete and result in a well-bonded joint.—*R. E. Thompson* (*Courtesy Chem. Abst.*).

Chile Has $200,000,000 Fund for City and State Public Works. Eng. News-Rec., **103**: 803, November 21, 1929. A brief outline is given of a huge program of national and municipal improvements for which $200,000,000 is available through loans from banks in the United States to the Government of Chile, included in which is a new water supply for Valparaiso. The present consumption is 32 m.g.d. to a population of 220,000, the existing works consisting of slow and rapid sand filters and chlorinating equipment. The new supply, which will be sufficient for a population of 500,000, will be drawn from the headwaters of the River Aconcagua. Storage for about 10 billion gallons will be provided and the aqueduct will be 120 miles long and have a capacity of 57 m.g.d. delivering into a reservoir in city sufficient for 1 day's supply. The water will be chlorinated only. The Chilean Government will expend $2,500,000 a year for municipal water works projects during a period of 6 years. The existing works of 70 cities (every plant in the country with the exception of one) will be im-

proved and new works provided for 36 cities now without a public supply. There are 3 existing slow sand plants and 2 under construction and 3 existing rapid sand plants and 3 under construction.—*R. E. Thompson.*

A Substitute for the Compression Test of Concrete. GEORGE J. GRIESENAUER. Eng. News-Rec., 103: 846–7, 1929. A rough method is described for determining the composition of plastic concrete. A 50-pound sample of the concrete is collected from the mixer and washed with water, the residue being surface-dried on paper pads and the wash water, containing the cement, allowed to settle, decanted, and the residue dried by heat. The dried cement is pulverized and passed through a 100-mesh sieve, the sand remaining on the sieve being added to the surface-dry sand and gravel. The gravel is removed from the latter mixture by means of a no. 4 sieve and any cement remaining in the sand is separated by screening on a 100-mesh sieve, that portion passing the sieve being added to the cement previously obtained. The 3 constituents are then weighed, the difference between the sum of these and the weight of the sample being the amount of water used in the mix. Strengths estimated by means of ABRAM'S water-cement ratio curve from results so obtained have consistently agreed with actual 28-day strength tests.—*R. E. Thompson (Courtesy Chem. Abst.).*

Dallas Reclaims 10,000 Acres in the Heart of the City. ALBERT S. FRY. Eng. News-Rec., 103: 804–8, November 21, 1929. A flood protection project now under construction at Dallas, Tex., will reclaim 9940 acres of land in the valley of the Trinity River. Within the limits of the project, the valley is about 7 miles long and 1 to 4 miles wide. Near the middle of the area the Elm Fork and the West Fork of the river unite to form the main Trinity River. Under the protection plan, floodwaters will be confined within a leveed floodway. The old channels of the 3 streams will be cut off and diversion channels will deliver the ordinary flow of the two forks to the floodway extending through the city and discharging into the present channel. The plan will require 26 miles of floodway levees, 15 miles of diversion channels, 2 miles of auxiliary channels, and 4 pumping plants.—*R. E. Thompson.*

Compiling and Preserving Detailed City Engineering Data. R. V. NEWCOMB. Eng. News-Rec., 103: 780, November 14, 1929. Brief outline of method of recording data water mains, etc., employed in Vermillion, S. D.—*R. E. Thompson.*

Rheology. I. The Nature of Fluid Flow. Eugene C. Bingham. J. Chem. Education, 6: 1113–9, 1929. From Chem. Abst., 23: 4119, September 10, 1929. A semi-popular treatment of the subject of the flow of matter. Some simple demonstrations are given of hydraulic, or turbulent, as well as of viscous, or linear, flow.—*R. E. Thompson.*

Theory, Measurement, and Application of pH Values. W. D. JARVIS. Elec. Times, 74: 80–1, 1928; Science Abstracts, 31B, 573. From Chem. Abst., 23: 4125, September 10, 1929. A discussion of the application H-ion concentration to the problem of corrosion of boilers.—*R. E. Thompson.*

Rapid Method for the Determination of Phenols. J. A. SHAW. Ind. Eng. Chem., Anal. Ed., 1: 118–21, 1929. From Chem. Abst., 23: 4165, September 10, 1929. With a special apparatus, easily made in any laboratory, 10 cc. of sample is steam distilled to give 25 cc. distillate. This is divided into portions, diluted until the concentration lies between 30 and 35 p.p.m., brought to 20°, treated with bromine water, and shaken. The turbidity is then instantly compared with that in 30 and 35 p.p.m. standards. Alcohols, amines, aldehydes, organic bases, oils, and inorganic salts interfere.—*R. E. Thompson.*

Tests of Metal Arc Welds. ANDREW VOGEL. Gen. Elec. Rev., 32: 332–9, 1929. From Chem. Abst., 23: 4174, September 10, 1929. Tests were made to determine unit stresses for design purposes and uniformity and reliability of the welds. The results establish unit stresses of 2000 pounds per linear inch for $\frac{1}{4}$-inch welds, 2500 pounds per linear inch for $\frac{5}{16}$-inch welds, and 3000 pounds per linear inch for $\frac{3}{8}$-inch welds and show that welding is uniform in strength and entirely reliable.—*R. E. Thompson.*

A New Fitting for Welded Pipe. E. G. LUENING. Ind. Eng. Chem., News Ed., 7: 14, 3–4, 1929. From Chem. Abst., 23: 4174, September 10, 1929.—*R. E. Thompson.*

Dichloramine. ROBERT M. CHAPIN. J. Am. Chem. Soc., 51: 2112–7, 1929. From Chem. Abst., 23: 4158, September 10, 1929. Dichloramine is produced by the chlorination of excess ammonium ions at pH 4.4 to 8.5; it is practically the sole ultimate product at pH 4.5 to 5.0. Monochloramine held at pH 4.4 to 5.3 undergoes extensive conversion to dichloramine. The reactions leading to dichloramine under the most favorable conditions require at least 1 to 2 hours for completion. A method is described for determining the percentage of dichloramine chlorine in total chloramine chlorine.—*R. E. Thompson.*

The Influence of Corrosion Accelerators and Inhibitors on Fatigue of Ferrous Metals. F. N. SPELLER, I. B. MCCORKLE and P. F. MUMMA. Proc. Am. Soc. Testing Materials 1929 (preprint) No. 41, 12 pp.; cf. C. A. 22: 2732. From Chem. Abst., 23: 4180, September 10, 1929. Under corrosion-fatigue, the endurance decreases as the chloride contents increase. In water with low saline content even a slight external influence causing local corrosion decidedly reduces the corrosion-fatigue endurance limit, even of stainless steels, either with or without inhibitors in the corroding solution. The strength of the inhibitor required to prevent failure increases with chloride concentration. Stress is essential, but probably plays only a minor part in directly accelerating corrosion.—*R. E. Thompson.*

Corrosion of Cast Iron. H. O. FORREST. Proc. Am. Soc. Testing Materials 1929, (preprint) No. 35, 61–70. From Chem. Abst., 23: 4180, September 10, 1929. Corrosion tests of samples of cast iron made by different processes have been made at M. I. T. by rotating small samples, cut from standard 8-inch pipe, in Cambridge water and measuring the loss in weight over time intervals up to 300 days. The average corrosion rate for the irons tested approximated

0.01 inch per year, the average deviation from the mean value of all samples being only 7 percent.—*R. E. Thompson.*

An Improved Technique for the Voges Proskauer Test. C. H. WERKMAN. Jour. Bact., **20**: 121–5, 1930. Review of existing tests is given, showing their defects. Method suggested utilizes ferric chloride as color indicator. A four day culture is used. To 5 cc. of such a culture are added 2 drops of 2 per cent aqueous solution of ferric chloride and 5 cc. of 10 percent solution of sodium hydroxide. The ferric chloride must be added before the sodium hydroxide. A bright copper color is given to the culture, if reaction positive. [This test as modified should be of practical value in routine control work.—ABSTRACTOR.] Controls using over 600 cultures have given excellent results.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

Is the Eijkman Test an Aid in the Detection of Fecal Pollution of Water? J. W. BROWN and C. E. SKINNER. Jour. Bact., **20**: 127–39, 1930. This test is used as a means of separating *B. coli* of warm blooded animal origin from characteristic strains derived from other sources. More than 1000 inoculations from human feces were used. Results indicate that absence of gas formation at 46°C. in glucose broth does not prove the absence of pollution. If gas formation is absent at 37°C., however, human fecal pollution is not present. It was also found that the addition of 1:100,000 crystal violet to the regular eosin methylene blue agar gave better confirmations than those given by the standard preparation. It was concluded that "many typical *B. coli* from a polluted stream failed to grow in the EIJKMAN broth at 46°C." It was also found that "only *B. coli*, never *B. aërogenes*, were present in human feces."—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

The influence of H-ion Concentration on the Sporulation of B. Welchii. JOHN C. TORREY, MORTON C. KAHN and MAY H. SALINGER. Jour. Bact., **20**: 85–98, 1930. The purpose of this work was to determine the H-ion concentration of an appropriate medium in which characteristic *B. Welchii* spores were obtained. The medium used was a sugar-free nutrient broth. The most favorable range of pH is from 6.8 to 8.0. [This may have some bearing on false presumptive *B. coli* tests.—ABSTRACTOR.]—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

The Bacteriophage Control of Sewage and its Action upon Bacterial Organisms. F. D. BECKWITH and EDYTHE J. ROSE. Jour. Bact., **20**: 151–60, 1930. Using sewage from various points in the purification process as collected in a certain plant it was found that bacteriophage is effective against many sewage organisms. Many strains of bacteriophage are chlorine resistant in relation to its use in sewage treatment.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

A Method of Staining Bacterial Flagella and Capsules together with a Study of the Origin of Flagella. EINAR LEIFSON. Jour. Bact., **20**: 203–13, 1930. A stain is described which is effective and easy to apply and can be used with or without a counter stain. This formula may also be used for a capsule stain.—*Edward S. Hopkins* (*Courtesy Chem. Abst.*).

New Treating Plants Yield 3 Percent. E. M. GRIME. Railway Age, 89: 9, 430–433, 1930. Complete field survey of "bad water" district on the Northern Pacific RR. in 1924 developed recommendations for program to improve water quality. Hardness of raw waters varied from 7.0 to 50.0 grains per gallon. Complete lime and soda ash plants were installed with reduction in hardness to 1.5 grains per gallon and five zeolite plants with reduction to 0.2 to 0.5 grain per gallon. Condition of locomotive boilers has greatly improved.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Kansas City Southern Expands Test and Inspection Work. M. A. HALL. Railway Age, 89: 11, 529–532, 1930. A testing department established by the Kansas City Southern Ry. now includes physical and chemical examination of materials purchased under specifications as well as check of water treatment at 19 lime-soda plants. Equipment includes modern dynamometer car for road tests. Results of water treatment are reflected in reduction in engine-leaking failures from 156 in 1921 to 22 in 1929. Sanitary water examinations are also handled.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Reservoir Replaces Well at Galesburg. A. W. JOHNSON. Railway Eng. Maint., 26: 9, 372–374, 1930. The Atchison, Topeka, and Santa Fe RR. has replaced 20-foot diameter by 75 feet deep dug well and water treating plant at Galesburg, Ill., with reservoir holding 675,000,000 gallons storage. Earth dam 870 feet long and concrete lined spillway were given special attention. Centrifugal pumps are operated by remote control approximately 4 miles distant. Quality of water was greatly improved.—*R. C. Bardwell (Courtesy Chem. Abstr.).*

Cleaning Water Pipes. R. N. FOSTER, F. T. BECKETT, and C. R. KNOWLES. Railway Eng. Maint., 26: 19, 394–395, 1930. Comparative economy in cleaning or renewing pipe lines depends upon condition and size of pipe. Pacified acid is best adapted for small lines, while mechanical cleaners are best for large sizes.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Producing Good Water Where There is None. Anon. Railway Age, 89: 11, 567–570, 1930. Wells drilled 1696 feet deep by the Union Pacific RR. at Bitter Creek, Wyo., failed to furnish water of satisfactory quality. A 13-mile pipe line from spring and small reservoir developed sufficient quantity to supply 600,000 g.p.d. Quality averages 46.3 grains per gallon dissolved solids, of which 22.4 are incrusting. Lime, soda-ash, and sodium aluminate treatment reduces total solids to 35.8 grains per gallon and incrustants to less than 2.5. Facilities consist of 21,000-gallon per hour softener, with 10 x 12 Roberts water motor proportioner, and 350,000-gallon storage tank with necessary service lines. Substantial saving has resulted.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Economical Features of Barium Treatment for Particular Waters and Best Practice for Locomotive Supplies. C. H. KOYL et al. Amer. Ry. Engr. Assoc. Proc., 31: 417–420, 1930. Use of barium in water treatment by railroads has

been restricted by high cost. The only such railroad plant now in operation is on the C. B. & Q. R.R at Edgemont, S. D. $BaCO_3$ is used with some Na_2CO_3, $Ca(OH)_2$, and sodium aluminate on artesian well water, 120°F., with 2 hours mixing and 20 hours settling. Total solids are reduced from 54.21 to 25.91 grains per gallon and incrustants, from 22.33 to 3.17. The advantage lies in reduction of total solids, which affect the foaming tendency.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Progress Report upon the Cause and Extent of Pitting and Corrosion of Locomotive Tubes and Sheets, Giving Consideration to Quality of Water, Character of Metals, Method of Manufacture, and Types of Boiler Construction. J. H. DAVIDSON et al. Amer. Ry. Engr. Assoc. Proc., 31: 411–413, 1930. Questionnaire developed that maintaining caustic alkalinity and providing a thin protective coating on water surfaces is the most universally applicable method of preventing pitting and corrosion.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Various Forms of Lime Treatment and Methods of Application. C. H. KOYL et al. Amer. Ry. Engr. Assoc. Proc., 31: 414–416, 1930. High Ca hydrated lime furnished in 50-pound paper sacks is used at practically all railroad lime-soda plants except on the A. T. & S. F. RR., where special storage provision permits successful use of unslaked lime.—*R. C. Bardwell* (*Courtesy Chem. Abst.*).

Final Report on Methods of Laying Cast Iron Pipe and Specifications for Inclusion in the Manual. F. D. YEATON et al. Amer. Ry. Engr. Assoc. Proc., 31: 421–429, 1930. Specifications cover trenching, pipe laying, joints of lead, cement, or substitutes, testing, and back-filling.—*R. C. Bardwell.*

Study and Report on the Storage of Water at Water Stations, Including Tanks, Standpipes, Storage and Sedimentation Basins, and Reservoirs. J. P. HANLEY et al. Amer. Ry. Engr. Assoc. Proc., 31: 430–440, 1930. Elevated tanks of wood or steel and standpipe type steel tanks are in general use, capacities varying from 4,000 to 750,000 gallons. Article is well illustrated and recommendations are given for service storage for various daily consumption demands.—*R. C. Bardwell.*

Concrete Water Tanks on the Duluth and Iron Range Railroad. R. A. TANNER. Amer. Ry. Engr. Proc., 31: 441–449, 1930. Long period of low temperatures caused freezing and leaking trouble with wood and steel tanks. Between 1920 and 1923, six concrete tanks were constructed. The typical design included 14-inch reinforced walls with 26-foot diameter by 25 feet high storage space at 16 feet elevation. The housed space under floor of tank is convenient for heating or pumping units. Some difficulty was experienced with joints between sides and floor which required special sealing arrangement with plastic material. Construction costs were reasonable and expected life is at least 40 years. Plans and photographs are given.—*R. C. Bardwell.*

Report on Zeolite Treatment of Water for Locomotives, Limitations of this Form of Treatment and Possibilities in Combination with Lime Treatment.

E. M. GRIME, et al. Amer. Ry. Engr. Assoc. Proc., 31: 450–462, 1930. History of material and descriptions of typical plants are given, together with comparative costs.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Progress Being Made by Federal and State Authorities Pertaining to Drinking Water Supply. R. C. BARDWELL et al. Amer. Ry. Engr. Assoc. Proc., 31: 464–465, 1930. A joint committee composed of representatives from the railroads and the Public Health Service is preparing recommendations for a Manual of Recommended Practice on Railway Sanitation.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Final Report on Methods and Practices of Securing and Handling Water for Drinking and Culinary Purposes by Railroads. W. B. MCCALEB et al. Amer. Ry. Engr. Assoc. Proc., 31: 465–469, 1930. To provide a drinking water which will pass the Treasury Department standards requires careful supervision and control.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Progress Report on Drinking Water and Coach Yard Sanitation. C. M. BARDWELL et al. Amer. Ry. Engr. Assoc. Proc., 31: 470–471, 1930. Account limited time available for watering through passenger trains, filling connection on cars should be simple and positive. Tapered metal nozzle over which plain rubber hose may be slipped is recommended.—*R. C. Bardwell (Courtesy Chem. Abst.).*

Long Distance Transportation of Water. E. A. BAYLEY. Water Works and Sewerage, 74: 481–3, 1929. Technical discussion of following factors in relation to long distance aqueducts: location of intake, storage requirements, topographic and hydrographic aspects, type of aqueduct, quantity of water transported, gravity or non-gravity aqueducts, generation of power, determination of gradient, and estimation of construction costs.—*C. C. Ruchhoft.*

Safeguarding Public Water Supplies. ARTHUR E. GORMAN. Water Works and Sewerage, 74: 475–6, 1929. The progressive water works operator should make intensive study of waterworks system, detect its weak points, and plan a definite program which will care for any type of emergency. Shortage of water supply, excessive rates of precipitation, and pollution by unusual industrial wastes are types of emergencies commonly encountered. The value of complete water works data in this connection is at once apparent. When emergency methods have been adopted, additional laboratory control measures are necessary in order to check their effectiveness. Meteorological data are of especial importance. Closer cooperation between water works officials and the public health officer is urged.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Recreational Use of Reservoirs. CARL WILSON. Water Works and Sewerage, 74: 473–4, 1929. According to a Committee on Sanitary Conservation of streams, the uses of water resources should have the following order of precedence: public water supplies, sewage disposal, navigation, manufacturing, industry, power, irrigation, fishing or recreation. Water supplies relying upon

natural processes for purification are ones that should avoid recreational use of reservoirs. The advantages of complete prohibition are technical and aesthetic. Both supply an additional factor of protection.—*C. C. Ruchhoft.*

Hartford Water Department Notes. C. M. SAVILLE. Public Works, 61: 32, 1930. Rather than construct additional slow sand filters at the West Hartford filter plant, prefiltration by rapid sand filters will be relied upon to furnish the necessary increased capacity. Recourse to this method was anticipated in the design of the initial installation. A waste survey resulted in detection of leaks aggregating 409,000 gallons per day. Tests were conducted to determine values of the coefficient of friction, *C*, for four large pipe lines. Data are given in tabular form.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

The Consumption of Water and the Effects of Metering. LYMAN M. VANDERPYL. Water Works and Sewerage, 74: 466–8, 1929. In study of water consumption, following classifications are generally used: domestic, industrial, commercial, public, and waste. Living standards are accurately indicated by domestic consumption, which high distribution pressures tend to increase. Industrial demand depends upon nature of industries served. Commercial demand includes that of stores, hotels, and apartment houses. Public requirements include water for schools, public buildings, parks, street sprinkling, and fire fighting. Waste includes leakage, underregistration of meters, and careless or wasteful use for purposes legitimate in themselves. Various tabulations all show that water consumption decreases as percentage of metered services increases. Metering also provides a check on item of wasted water. Tables showing consumption and effects of metering are included.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Control of Filter Washing, EDWARD S. HOPKINS. Water Works and Sewerage, 74: 490, 1929. Clarity of final wash water is a usual criterion of cleanliness of filter bed. Final wash water turbidities in the cases of seven experienced filter operators showed variations all the way from 25 to 150 p.p.m. as determined by visual methods. Using a constant filtration rate and applying a properly coagulated water with turbidity between 4 and 7 p.p.m., it was shown that minimum final wash water turbidity results in maximum period of filter operation. Further experiments showed that filter runs are practically constant for a final wash water turbidity of 75 p.p.m. According to data secured, following washing procedures are indicated: for wash velocities of 2.3, 2.7, and 2.9 feet per minute of vertical rise, corresponding washing times should be 6, 4, and 4 minutes, respectively. Adherence to this schehule will assure maximum filter runs, provided, of course, that the increased velocities can be used without loss of sand.—*C. C. Ruchhoft* (*Courtesy Chem. Abst.*).

Study of Chlorine Efficiency. (From Progress Report of Committee on Water Purification and Treatment of the Conference of State Sanitary Engineers.) Public Works, 61: 26–8, 1930. Object of the Committee is to collect from water purification plants located in various sections of the country data bearing on the efficiency and reliability of chlorination, with view primarily

to determine whether chlorination should be considered as an external factor of safety to filtration processes, or as an integral part of such processes, and secondarily to determine the normal efficiency ratio for water chlorination and factors affecting the same. The data collected to date have warranted the following recommendations. (1) Filtration processes unaided by chlorination cannot produce effluents conforming to the revised Treasury Department *B. coli* standard, if the average *B. coli* index of the raw water exceeds an amount falling below that of a large majority of raw water supplies being delivered to filtration plants. (2) The time required to attain a given degree of bacterial reduction appears to bear a fairly definite inverse relation to the concentration of residual chlorine. (3) Bacterial efficiency of chlorination is affected by temperature, being greater at higher temperatures. (4) The presence of chlorine-absorbing substances affects the dosage of chlorine necessary to produce a given efficiency; but, since the controlling factor is the residual chlorine content, the effect of the chlorine-absorbing substances on the efficiency is only indirect. (5) Prechlorination appears to be establishing itself rapidly as an added stage of purification in connection with rapid sand filtration of variable and highly polluted raw waters.—*C. C. Ruchhoft (Courtesy Chem. Abst.).*

Balbriggan and Skerries, Ireland, Water Supply. Jos. G. Wade. Water and Water Eng., 32: 377, 203–207, May 20, 1930. Skerries, near Dublin, is situated on a flat plain about 25 feet above Ordinance Datum. It has a maximum summer population of 3,000. Increasing water needs resulted in search for gravity supply, deep wells being unsuitable. A position a few miles distant was selected and as pipe line had to pass near Balbriggan, latter locality of 2,000 persons was included in scheme. A storage reservoir of 30 million gallons was decided upon and a bottle-neck site chosen. Construction of the dam, overflow weir, and valve tower is described. Over six months were required to fill the reservoir, which is 1350 feet long. From the dam, water gravitates to a service reservoir on high ground above Balbriggan, capacity of which is 375,000 gallons, or two days' supply for the two towns. Construction details of this reservoir are also given. The mechanical-type filtration plant includes three units, each of rated capacity of 3,000 gallons per hour. Filters and chemicals are suitably housed.—*Arthur P. Miller.*

Watersheds as National Parks. Anon. Water and Water Eng., 32: 377, 211, May 20, 1930. Evidence submitted to National Parks Committee by general manager of Sheffield (England) Corporation Water Department revealed that, without exception, authorities in charge are definitely opposed to use of watersheds as public parks, or recreation grounds, without adequate safeguarding of water supplies. Many corporations have purchased the whole, or greater part, of their catchment areas; but some still have not. It is brought out that object in purchasing catchment areas would be nullified, if public were given unrestricted use of them for recreation. Inaccessible watersheds are now a thing of the past; frequentation for recreation by the public would probably vary inversely in accordance with distance from centers of population. Authorities are directed by law to furnish a wholesome water

supply and it is contended that opening of catchment areas for recreation is in direct conflict with this duty. In summer, when water storage is at its lowest, the grounds would probably be put to greatest use. This would introduce maximum hazard at the worst time. Another question of importance is that of fire on watersheds which have been planted.—*Arthur P. Miller.*

Two-Stroke Cycle Gas-Displacement Pump. The Christie Large Volume Low Head Pump. Anon. Water and Water Engineering, **32**: 377, 218–220, May 20, 1930. The gas-displacement pump is suitable for handling large volumes of liquid at low heads. The Christie large-volume low-head pump is simple in design and operation and adaptable to varying loads. One of these pumps installed at Exeter, England, is described and its method of operation given in some detail.—*Arthur P. Miller.*

Water Supply from Boreholes. H. T. Burgers. Water and Water Eng., **32**: 377, 221–224, May 20, 1930. Use of boreholes for irrigation purposes is of doubtful expediency and can only be economically sound when head against which pump has to operate falls below the critical value beyond which pumping costs will surpass any possible profit from irrigated area. In South Africa, artesian conditions are quite exceptional; boreholes must almost always be pumped, and are usually relied upon only for small-scale supplies for domestic use, or for small gardens, or for watering stock. In locating boreholes, geological study of the area is helpful as is also a review of results obtained from other drillings in that particular area. Water can normally be found at no very great depth beneath the surface in South Africa. Out of 800 boreholes sunk by the writer, only five percent were failures before completion. Water divining and location of underground water by televising means are briefly discussed.—*Arthur P. Miller.*

Elimination of Taste and Odor in Drinking Waters. Systems of Treatment. Anon. Water and Water Eng., **32**: 377, 225–226, May 20, 1930. Review of present day practice in connection with super- and de-chlorination, pre-ammoniation, permanganate treatment, and activated carbon. The progress being made in all these phases of water purification work in America and in Europe is touched upon.—*Arthur P. Miller.*

Some Views on the Purification of Surface Water for Drinking Water Supplies. C. M. Wichers and E. Jacobs. Water and Water Eng., **32**: 377, 227–230, May 20, 1930. During 1927 and 1928 extensive investigations and observations were made at the Groningen, Holland, Waterworks, chiefly relating to biological (slow sand) filtration. Most of the work was done with experimental filters four square meters in area treated by same methods used at the works. Conclusions drawn include following. (1) Removal of color from peaty waters may be effected without chemicals by admixture with ferruginous ground water, aërating, and filtering. (2) Organic matter assimilable by a filter has the injurious effect of promoting growth of organisms in the surface film, thus indirectly blocking the filter. (3) No relation between loss of head and meteorological conditions could be found. (4) The working of a biological sand filter

is three-fold; each of these phases was studied and a number of conclusions drawn. (5) Rate of filtration. If rate of filtration is increased, quantity of water filtered between successive cleanings will generally increase, as will also quantity of organic matter oxidized per unit of time and number of bacteria destroyed; on the other hand, indices of quality will have tendency to decrease. Up to four times the usual rate, the differences are of little importance. No critical rate could be found. Quality of filtrate is so influenced by quality of raw water as to render rate of filtration up to four times the usual rate of no importance. (6) Turbidity determination. Excellent results were obtained with Dr. MOLL's extinction meter, in which the transparency is measured by means of two thermocouples. (7) Sand specification. Writers consider American method of characterizing filter sand as too rough. They prefer to estimate total surface area of sand grains per cc. of moist sand and voids per gram of firmly packed sand. These two factors, easily determined, are of direct importance in filtration practice and are typical for each sand.—*Arthur P. Miller.*

When Are Laws Compelling Water Bill Payments Valid? LEO T. PARKER. Water Works Eng., **83**: 16, 1139, July 30, 1930. A city ordinance or regulation of a water company is invalid which imposes a lien upon premises to secure payment of a tenant's water bill, unless a state law or city charter clearly delegates such authority. Courts have held that reasonable rules may be enacted to collect water bills and water company has authority to discontinue service for non-payment of bills. If the statutes provide for shutting off water when bills are unpaid, the bill cannot be collected from property owners after the first month. If the water company turns on water by instructions from tenant, the landlord is not responsible for the bills.—*Lewis V. Carpenter.*

New Ottawa Purification Plant Based on Data from Small Model. E. G. WILSON. Water Works Eng., **83**: 17, 1207, August 13, 1930. Channels or key ways in the solid rock bottom of the excavation were cut without dynamite by drilling holes at 6-inch centers and removing the rock by plugs and feathers. The plant has three sets of mixing chambers with eight chambers in each set, each 16 feet wide by 17 feet long by 30 feet deep. There are three settling basins, each 30 feet wide by 301 feet long by 30 feet deep. Ten filters, each of 3.4 million imperial gallons per day capacity, are to be used and provision is made for 10 more to be added when needed. The 20,000 cubic yards of concrete is being proportioned according to the water-cement ratio theory, with a testing plant controlling the mix. The concrete is designed for 1800 pounds per square inch compressive strength. The designers have incorporated the ideas obtained from their experimental plant.—*Lewis V. Carpenter.*

Good Results from Operation of New 24-M.G.D. Filtration Plant. A. B. JEWELL. Water Works Eng., **83**: 18, 1277, August 27, 1930. Tulsa, Okla., plant can use Mohawk Lake for plain sedimentation. This gives a detention period of 20 to 30 days. Water is aërated by forcing air through a series of Filtros plates set in the bottom of the raw water flume. Cost of power for aëration is about 30 cents per million gallons. Lime is added before aëration

and then alum is added to circular mixing flumes. After a 4-hour settling period the water is filtered. Operation of the plant has been very gratifying. The average turbidity of the finished water has been 0.1 p.p.m. and *B. coli* have been entirely removed. Some trouble was caused by *Daphnia* and it was necessary to add 0.9 p.p.m. of chlorine to get rid of them. The cost of delivered water is $5.89 per m.g. exclusive of fixed charges.—*Lewis V. Carpenter.*

Can Water Works Go Outside Charter in Making Contract to Supply Water? LEO T. PARKER. Water Works Eng., 83: 18, 1276, August 27, 1930. A municipal corporation has no power to cede away its legislative or governmental powers by contracts with others so as to disable it from the performance of its public duties and when a contract is made by such corporation, the governing body of such city has at all times the right to declare it void and to refuse compliance therewith. Author cites court decisions on laws of easement, validity of water works bond issues, and free water at expiration of franchise. The law is well established that a municipality is not liable in damages for injury, unless the defect causing the injury had been in existence sufficient time for the city to correct the defect.—*Lewis V. Carpenter.*

Some Observations Concerning the Ammonia Determination in Water. M. W. E. EVERS. Verslagen en Mededeelingen betr. de Volksgezondheid, 1930: 7, 1089–1103. Appendix No. 3 to Annual Report for 1929 of Government Water Supply Bureau. Account of experiments to ascertain (1) lower limit of alkalinity at which ammonia recovery is complete by simple distillation without alkaline addition; and (2) whether, of the three substances magnesia, sodium carbonate, and calcium carbonate, any one is to be preferred to the others for ammonia expulsion purposes. It was found that 37.5 p.p.m. of alkalinity sufficed in all cases to ensure complete recovery of ammonia in the distillate up to 10 p.p.m. of ammonia; when total hardness was very low, even less alkalinity sufficed; but it is simpler and safer to disregard such exceptions. Calcium carbonate is given the preference as alkaline reagent; but either magnesia or sodium carbonate will give satisfactory results.—*Frank Hannan.*

NEW BOOKS

Military Preventive Medicine. Army Medical Bulletin No. 23, 1930. GEORGE C. DUNHAM. Published by the School Press, Army Medical Field Service School, Carlisle, Pa. A comprehensive textbook for medical officers of the Army, National Guard and Reserve officers. The subject is presented in a brief and thorough manner. The treatise deals with matters which concern the care and health of troops. It deals with the biological enemies of man, especially those encountered by troops in peace and war. The chapters dealing with water, wastes, air, food and light and other environmental surroundings are convenient for ready reference. The pasteurization of milk supplies is emphasized. The water supply is dealt with from procurement to purification and laboratory procedure to determine the potability of water supplies. Improvised chlorinators are clearly described. Waste and sewage disposal are presented briefly and description of emergency appliances readily understood.

Housing, ventilation and personal hygiene show the value of lessons learned in the past. The chapters on communicable diseases are clear and concise, treating with modes of infection and measures of control and immunization. Venereal disease control is adequately and succinctly dealt with. The description to prevent cross infection by droplet or air transmission of respiratory tract discharges is simple and practical. The text is not only of interest and value to medical officers, but should be of assistance to line officers in instituting measures for the care of their troops in garrison and field. The work is well illustrated and should serve as a guide in installation and construction of sanitary appliances. Local health officers, especially those who have rural sanitary conditions to meet, will find the book of value in assisting in the solution of their problems.—*C. H. Halliday.*

Prechlorination of Water Supplies. Technical Publication 132 of Wallace and Tiernan Co. Inc. **I. Prechlorination of Water Supplies.** Municipal Index, 1930. WELLINGTON DONALDSON. Author defines prechlorination as the routine application of hypochlorite or chlorine at any point ahead of filters in doses not requiring the subsequent use of anti-chlor or dechlorination treatment. The practice was developed in Europe at Middelkerke, Belgium, in 1902 and at Lincoln, England, in 1905. In America, it was inaugurated by JOHNSON in 1908 at the Bubbly Creek filter plant at Chicago. Numerous other cities in America followed, but largely discontinued the practice when the post-chlorination treatment was adopted. Increasing pollution of raw water supplies was instrumental in the revival of prechlorination in 1921 since when its use has extended in all directions. The various advantages claimed include reduction of bacterial loading on filters, permitting better and more consistent over-all quality than is possible with effluent chlorination alone, increased factor of safety, improved coagulation resulting in better clarity of effluent with lower residual iron and alumina, reduction of coagulant required, better color removal, prolongation of filter runs with resulting economy of wash water, sand beds cleaner in appearance and free from cracks and mud balls, plankton life in basins and filters kept under control, suppression of grosser biological growths in raw and settled water conduits and on basin and filter walls and gutters, putrefactive conditions in basin sludge deferred, elimination of taste, and reduction of operating costs. Raw water is said to be the best point of application, because of the longer contact time and higher safety factor in case of interrupted feed. Details are given of operating results at numerous plants in addition to an extensive bibliography covering a period ranging between 1906 and 1930. **II. Benefits Derived from Prechlorination.** JOHN J. QUINN. A. W. W. A. Kentucky-Tennessee Section, January 23–25, 1930. Clear and detailed exposition of remarkably favorable results from prechlorination obtained at the Knoxville, Tenn., Filter Plant in October, November, and December 1929, the first three months of its application.—*Norman J. Howard.*

The New Automatic Residual Chlorine Recorder and Controller. J. WESTFORD CUTLER and FRANK W. GREEN. Technical Publication 135 of Wallace and Tiernan Co. Reprint from this JOURNAL, **22**: 6, 755–766, June, 1930.—*Frank Hannan.*

Formation and Properties of Boiler Scale. EVERETT P. PARTRIDGE. Engineering Research Bulletin No. 15, June, 1930, University of Michigan. Substantially complete presentation of existing knowledge of subject. It considers the boiler scale problem not wholly as one of correction, but also as one of prevention, through understanding its method of formation and its properties. The author's own conclusions summarize well the contents of the four principal parts of the bulletin. Part I:

"Boiler scales have low heat conductivities; the maximum value of the heat-conductivity coefficient is approximately 2.0 B. t.u. per square foot per hour per foot per degree F. Dense, compact scales, such as are typically formed by calcium sulfate, show an average value of approximately 1.3, while very porous scales may have coefficients as low as 0.05. The extreme low conductivity of porous scales is due to the fact that, during actual boiler operation, the interstices are filled with steam, forming what is, in effect, a vapor film mechanically held on the boiler heating surface. The high resistance of vapor films to heat flow is well known. While boiler scale is a material with low heat conductivity, its effect upon heat utilization is slight. Older figures for heat loss due to scale range up to 15 percent loss for $\frac{1}{16}$ inch of scale; but it is probable that the actual loss is not more than 2 per cent. The latter figure is supported, not only by theoretical calculations, but also by the result of recent experimental investigations. Even though scale has a less serious effect on boiler efficiency than was formerly believed, scale formation upon boiler heating surfaces exposed to direct radiation has a serious effect on the elevation in metal temperature. Rates of heat transfer by radiation of 75,000 B.t.u. per square foot per hour, or over, have been estimated for front-row and waterwall tubes in contemporary installations. With such high rates, deposits of non-porous scales of the order of thickness of 0.05–0.10 inch will cause failure of tubes by overheating, while extremely porous scales of one-tenth the thickness may produce the same result. Since increase in boiler pressure decreases the allowable margin of elevation in the tube temperature, the problem of scale prevention will become continually more important as boiler pressures and ratings increase."

Part II:

"Chemical analysis and crystallographic examination of boiler scales indicate that calcium sulfate in the form of anhydrite, calcium carbonate in the form of calcite, magnesium hydroxide in the form of brucite, and magnesium silicate and calcium silicate are the most common constituents, while calcium carbonate in the form of aragonite and calcium hydroxide are occasionally present. The crystallographic data necessary for identification of all of these constituents of boiler scale with the exception of calcium silicate and magnesium silicate are tabulated. The solubilities of the three forms of calcium sulfate, of magnesium hydroxide, and of calcium hydroxide are known in the boiler temperature range. All of these scale-forming substances decrease in solubility with temperature increase. It is highly probable, as indicated by FREAR and JOHNSTON, that solubility of calcite likewise decreases as the temperature is raised, the partial pressure of carbon dioxide being held constant. The solubility

of calcite at a given temperature also decreases with decrease in the partial pressure of carbon dioxide. While no information is available concerning calcium and magnesium silicates, it is believed that these substances also show solubility curves with negative slopes. If this assumption is granted, the generalization may be made that all of the substances commonly occurring in boiler scale are characterized by negative solubility slopes. The question of solubility equilibria in the complex solutions presented by the water in boilers during actual operation may probably be treated most accurately and most simply from the standpoint of activities, rather than from that of ionic concentrations. Work is in progress at the present time in an attempt to define HALL's carbonate-sulfate ratio in terms of activities as a function of the ionic strength of the boiler water. A preliminary comparison is given of solubility products calculated respectively from the ionization data of NOYES and from the tentative ionic activity coefficients of LEWIS and RANDALL."

Part III:

"Scale deposition and growth on the heating surfaces of boilers is due chiefly to the fact that certain slightly soluble substances become less soluble with increase in temperature. Some initial deposition of scale crystals by sedimentation, or by trapping in surface irregularities, may take place in boilers of the horizontal return tubular or marine types, but it is probable that scale formation in the tubes of water-tube boilers is due to an entirely different action. The initial deposition of scale crystals is generally the result of crystallization at the boiler surface from a solution which is supersaturated with respect to the scale-forming substance. The whole body of a boiler solution constantly tends toward a state of supersaturation as steam is removed; in addition, since scale-forming substances decrease in solubility with increase in temperature, the film of boiler water adjacent to a heating surface tends to be supersaturated even when the body of the solution is only at the saturation point. Supersaturation in the liquid film at the heating surface may be relieved by spontaneous crystallization, possibly promoted by irregularities in the surface, even when no vaporization is taking place. When bubbles are being evolved at the heating surface, however, the excess solute is deposited as minute crystals in rings directly at the solid-liquid-vapor interfaces formed by the metal surface, the boiler water, and the bubbles forming in contact with the surface. This latter action undoubtedly accounts for the deposition of practically all of the initial scale nuclei on boiler surfaces at which actual vaporization of water is taking place. The growth of scale following initial deposition of crystal nuclei may proceed in either of two ways. The existing crystals may grow by contact with the supersaturated liquid film with which they are continuously in contact; or, if these crystals are removed from contact with the solution, as by the adsorption of a film of a colloidal substance present in the boiler water, further deposition of new crystals superimposed on the previous deposit may take place as the result of bubble evolution. In the first case the resulting scale will consist chiefly of relatively large continuous crystals oriented more or less perpendicularly to the heating surface; in the second case, the scale will

consist of relatively small crystals with a random orientation. The rate of scale growth is probably a function of two chief factors, the slope of the solubility curve of the scaling substance and the rate of heat transfer across the surface to which the scale is attached. Using the nomenclature:—

S = solubility of scaling substance
T = temperature
Q = amount of heat transferred
t = time
D = amount of scale deposited
K = a coefficient, constant for each scale-forming substance
m, n = constants, probably approximately equal to unity

the rate of scale growth may be expressed hypothetically by the equation:

$$\frac{dD}{dt} = -K\left(\frac{dS}{dT}\right)^m \cdot \left(\frac{dQ}{dt}\right)^n.$$

The velocity of fluid flow past the heating surface and the presence in the fluid film of suspended scale crystals may exert a retarding action on the rate of formation, the magnitude of which cannot be estimated at the present time. This effect is, however, probably relatively insignificant."

Part IV is a critical discussion of various methods of scale prevention in the light of the theory of formation formulated in the preceding parts. Distillation of make-up, precipitation of undesirable ions, ion replacement, use of materials upon which scale will not deposit, electrical systems, boiler compounds and colloid treatment, and internal treatment with inorganic chemicals are considered. The author concludes:

"Internal treatment with organic colloids may have some possibilities for use in boilers not driven at high ratings under high pressure. No reputable engineer, however, will allow the use of a boiler compound, or colloid treatment, the composition of which is not known to him. Electrical systems for the prevention of scale are not well based theoretically and they have not yet been demonstrated on a satisfactory practical basis. An impartial investigation of both colloid and electrical methods of scale prevention is recommended. Where the most severe demands are made upon a boiler installation, the choice will probably lie between the distillation of make-up water, a zeolite softening system, or the combination of external hot-process lime-soda softening with internal phosphate conditioning. For less exacting service, the lime-barium softening system is approximately on a par with the hot-process lime-soda system. Where conditions permit, internal conditioning with carbonate will probably always have a very general application."

Each part of the bulletin is supplemented by a bibliography. The bulletin also carries four appendices giving detailed data and results of laboratory studies and experiments in connection with the general subject. These appendices embrace scale-formation tests in an experimental boiler, the crystal forms of calcium sulfate, the solubilities of the crystal forms of calcium sulfate, and a photomicrographic study of scale formation. The chemist or engineer who wishes to acquire a thorough understanding of the nature and properties of boiler scale should refer to the complete text for much valuable data which cannot be abstracted here.—*R. L. McNamee.*

Illinois River Studies 1925–1928. C. S. Boruff and A. M. Buswell. Illinois State Water Survey, Bulletin 28. 127 pages. Result of surveys and analyses of the Illinois River indicate that up to 1920, the middle section, LaSalle to Peoria Narrows, was becoming more highly polluted. The results during 1923–1925 were rather irregular due to extremely low or high water. However, during 1926–1928, this section of the river definitely showed a tendency toward higher dissolved oxygen content. The year 1920 probably marks the period of maximum pollution load. The improvement is probably due to a decrease in the industrial load from organizations such as the Corn Products Refining Company located in the Sanitary District of Chicago. The Illinois River below Peoria, i.e. Kingston Mines to Beardstown, seems to be becoming more polluted since 1925 as indicated by the decreased dissolved oxygen and the increased biochemical oxygen demand load which is the oxygen demand multiplied by the flow of the river expressed as thousands of cubic feet per second. The bacterial quantity unit which is the total count per cc. multiplied by the flow in thousands of cubic feet per second is constant, or decreases, for the stations of Peoria Narrows and above; but, like the biochemical oxygen demand load, increases for Kingston Mines and Beardstown. Physical conditions, especially between Peoria and Pekin and below this latter city for some miles, tend to show each summer season signs of an increasing pollution load. The extra load that is being added to the river is due to the increased population of the Pekin and Peoria districts as well as to the very marked increase in industrial wastes.—*G. P. Edwards* (*Courtesy F. W. Mohlman*).

Proceedings Fourth Annual Conference, Maryland Water and Sewerage Association, May 13 and 14, 1930, Hagerstown, Maryland. 119 pp. **Automatic Water Pumping Stations.** Leon Small. 5–23. Elements of design entering into automatic electric water pumping stations, with description of stations built for Baltimore water supply, are given. Main portion of housing of station is built below ground with 18 inches earth cover. The stairwell entrance is surrounded by an 8-foot square brick structure with doors at top and bottom of stairs. The roof is made with a removable section to allow for handling machinery. Electric service is brought in under ground which tends to reduce danger of interruptions due to lightning. Squirrel-cage motors are generally preferable. Motor start-and-stop control may be actuated by float switch in elevated tank, by separate pressure line from tank to station, or by an altitude valve at the tank; the last preferred. Centrifugal pumps are generally best adapted to under ground installations. Discharge valves are hydraulically operated and automatically controlled so that the pump in starting is brought up to speed before the valve is opened. The author concludes with interesting description of Catonsville automatic station of the Baltimore system. **The Significance of Necessary Tests at Small Water Works Plants.** J. M. Jester. 39–47. Clear non-technical discussion of simple routine determinations, including methods of sampling and tests for turbidity, pH, hardness, residual chlorine, and tastes and odors. **Preparation of the Grading Schedule of the National Board of Fire Underwriters.** A. C. Hutson. 53–61. The evolution of the grading schedule and some of the more important con-

siderations upon which it is based are discussed. Checks of the conditions observed during large fires and recommendations of the grading schedule indicate latter are reasonable. **Regular Supervision of Institutional Water and Sewage Treatment Plants in Maryland.** A. W. BLOHM. 69–76. Maryland state institutions each contribute to a fund to provide salary and expense for an engineer to supervise regularly operation of institutional plants. Visits are made not less than once per month; records are checked and operators are instructed. Plan meets with favor from administrators of institutions. **Maintenance and Operation of New Potomac River plant and 24-inch pipe line.** J. CHESTER BREWER. **Water Department Hagerstown, Md.** 100–109. Hagerstown's new 10 m.g.d. plant, consisting of river intake, screen chamber, low lift pumps, settling basins, mixing chambers, coagulation basin, filters, clear water storage, high-service pumps and 24-inch force main, is described in detail. Operating costs per million gallons for the year ending December 31, 1929, were:

Power	$21.05
Labor	9.59
Coagulants	2.05
Chlorine	0.23
Heat	2.00
Laboratory	2.44
Sundries	0.61
Total	$37.97

Personnel consists of superintendent, chemist, two operators, two assistant operators, and a day laborer.—*R. L. McNamee.*